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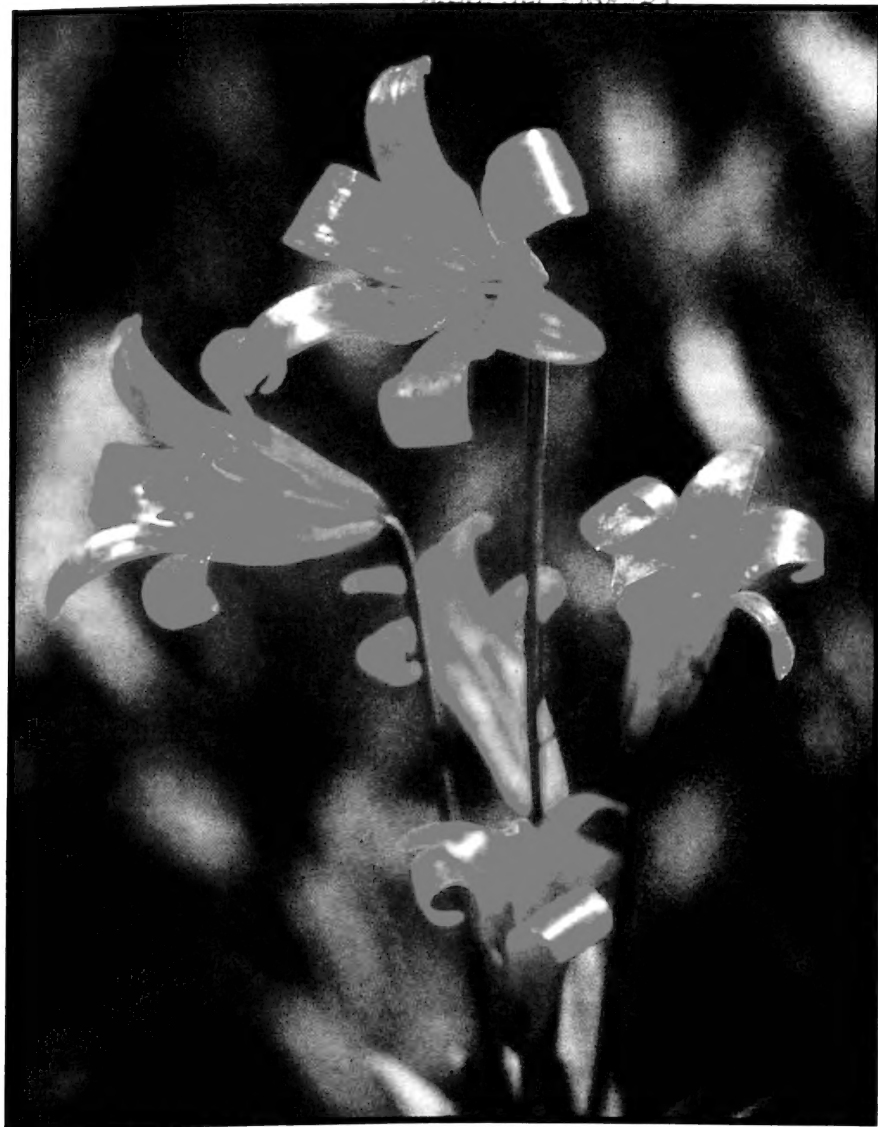
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International Journal of the American Plant Life Society, devoted to the increase and diffusion of knowledge on bulbous plants and petaloid monocot families, especially the Amaryllidaceae.

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IN THIS ISSUE . . .

We have now launched into the coverage of bulbous monocots with the inclusion of a survey article on *Lilium*, as well as an article on the cytology of *Gloriosa*. The repatriated Dr. Stone gives us an overview of the *Hypoxidaceae*. Dr. Koopowitz has prepared in print some of the material he presented at the 1985 New Orleans Convention. An active plant conservation worker, Jose Alberto Castillo, provides us with information on certain bulbous plants from his region.

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Cover: *Lilium parvum*, from a color slide by Wayne P. Armstrong.

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CYTOLOGY OF THREE SPECIES OF *GLORIOSA* L. (LILIACEAE)

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DIVISION OF ORNAMENTAL CROPS

INDIAN INSTITUTE OF HORTICULTURAL RESEARCH

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CONTRIBUTION NUMBER 132/85

Gloriosa L. (Liliaceae) is a small genus of 5-6 species (Anon. 1976) endemic to Asian and African tropics. These are tuberous, weak stemmed climbers bearing curiously reflexed yellow and red flowers. *G. rothschildiana* is widely cultivated for its ornamental flowers; white *G. superba* is a well known alternative source of alkaloid colchicine (Subbrathnam 1952).

A number of studies have been made on the cytology of *Gloriosa* [Sato 1942; Tjio 1948; La Cour (cf. Fedorov 1969); Khoshoo 1956; Sharma and Sharma 1961; Mehra and Sachdeva 1976; Narain 1977; Lemattre 1980]. Basic chromosome number of the genus is 11; euploids ranging from diploid to octoploid ($2n = 22 = 88$) and aneuploids with numbers 14, 84 and 90 have been reported (for details see discussion). However, the genomic interrelations within and among species have not been adequately worked out. Present studies on somatic chromosome morphology and male meiosis of *G. superba*, *G. carsonii*, and *G. rothschildiana* were carried out in order to reveal the chromosome variations and relationships in the genus.

MATERIALS AND METHODS

Of the 3 species studied, only *G. superba* exists wild in India. It was collected from Bannerghatta National Park in Karnataka. Tubers of this species were also collected from Universal Nursery, Kalimpong and G. Ghose & Co., Darjeeling where the other two species, *G. rothschildiana* and *G. carsonii*, were procured.

Actively dividing root tips, obtained by placing tubers in moist sand, were prefixed in saturated solution of paradichlorobenzene at 12° C. After 3 hours these were thoroughly washed and fixed in 1:3 acetic-alcohol mixture for 24 hours. Squashes were prepared in 1% acto-orcein after hydrolysis in 9:1 mixture of acto-orcein and 1N HCl at 60° C for 5 minutes. The karyotypes were classified according to Levan *et al.* (1964). Following abbreviations have been used: L—long; S—short; M—centromere median; m—centromere in median region; sm—centromere submedian; st—centromere subterminal; t—centromere in terminal region.

Buds in proper stages of male meiosis were prefixed in a mixture of 6 absolute alcohol, 3 chloroform and 1 acetic acid for 15 minutes. Anthers were smeared in 1% acto-orcein and studies made from fresh slides. Pollen stainability was determined with 1% acetocarmine.

OBSERVATIONS

GLORIOSA SUPERBA

Karyotype: All 3 collections were diploid with 22 somatic chromosomes. Detailed karyotypic studies were made on the Bannerghatta population. The chromosomes grouped into 11 homomorphic pairs; 3 long and 8 short (Figure 1, Table I). Centromeres in 3 short pairs were submedian; in all the rest these were median or in the median region. Total chromatin length of the karyotype was 100.2 μm .

Karyotype formula: $4\text{ L M} + 2\text{ L m} + 2\text{ S M} + 8\text{ S m} + 6\text{ S sm}$.

Meiosis: At metaphase I, 11 II were observed in majority of cells (Figure 2, Table II). In 10.6% of the cells, associations of 10 II + 2 I were found (Figure 3). The unpaired chromosomes were small in size and had most likely originated by precocious separation of a bivalent. Chiasma frequency at MI was 13.90 per cell (11.13 terminal and 2.77 interstitial). Anaphase I segregation was regular (11:11) in all but 3 of the 24 cells studied. In one, the distribution was 10:12 while in the other two, one chromosome was found lagging at the equator. Pollen stainability was 96.2%.

GLORIOSA CARSONII

Karyotype: Two collections of this species studied for cytology were tetraploid with 44 somatic chromosomes. These grouped into 11 homomorphic quadruplets; 3 relatively long and 8 short (Figure 4, Table III). Seven quadruplets had centromeres in the median region, 2 had submedian and the other 2 subterminal. The total chromatin length was 149.2 μm .

Karyotype formula: $12\text{ L m} + 16\text{ S m} + 8\text{ S sm} + 8\text{ S st}$

Meiosis: Associations of quadrivalents and bivalents were observed at metaphase I (Figures 5 & 6, Table IV). In 19% of the cells, a maximum of 3 IV was observed, whereas in 4% of the cells only bivalent configurations were observed. Average per cell chromosome association at this stage was 1.85 IV + 18.30 II. Majority of the quadrivalent associations were formed by long chromosomes, although in a few cells small quadrivalents were also present. Of the 90 IV's observed in 50 cells, 85 were ring, 3 chain, and 2 frying pan type. Chiasma frequency at metaphase I was 28.94 per cell (23.08 terminal and 5.86 interstitial).

Anaphase I segregation was equal (22:22) in 81.2% of the cells (Figures 7 & 8, Table V). The rest showed unequal distribution, laggards or precociously separating chromatids. In 11.2% of the cells bridge-fragment configurations were observed. At telophase I, 1-2 laggards were observed in 4.7% of the cells. Pollen stainability was 87.1%.

GLORIOSA ROTHSCILDIANA

Karyotype: Tubers of this species were obtained from two nurseries. Both the collections turned out to be octoploid having 88 somatic chromosomes. Ranging between 5.2 μm and 0.7 μm these matched into 11 groups of 8 chromosomes each—3 long and 8 relatively short (Figure 9, Table VI). Ten of these groups were homomor-

phic while the last one was heteromorphic. Centromeres of 8 homomorphic chromosome groups were in positions ranging from median to submedian. Of the other 2, one had subterminal and the other nearly terminal centromeres. The heteromorphic group had 2 longer chromosomes with centromeres in the median region, 4 shorter, and 2 extremely small chromosomes; the latter two types had subterminal centromeres. The total chromatin length of the karyotype was 223.0 μm .

Karyotype formula: 24 L m + 8 S M + 16 S m + 16 S sm + 8 S st + 8 S + + 8 S m-st.

Meiosis: Configurations ranging from octovalents to univalents were observed at metaphase I (Figures 10 & 11, Table VII). Range per cell of these associations was 0-1 VIII, 0-2 VI, 0-5 IV, 0-1 III, 30-43 II, 0-6 I. Average per cell association was 0.06 VIII + 0.52 VI + 1.96 IV + 0.02 III + 37.20 II + 2.10 I. Of the 23 cells studied at anaphase I (Figures 12 & 13, Table VIII), 8 showed regular 44:44 segregation. The rest had unequal distribution ranging up to 47:41. Laggards, 1-4 in number, were observed in 60.8% of the cells. Pollen stainability was 76.4%.

DISCUSSION

Chromosome numbers recorded so far in the three species are given in Table IX. Perusal of the table reveals that all authors, except Sharma and Sharma (1961), report the numbers to be direct multiples of base number 11. However, there is a wide range of polyploids recorded within each species. *Gloriosa superba* and *G. rothschildiana* each seem to possess a series of euploids ranging from diploid to octoploid while in *G. carsonii* tetraploid and heptaploid cytotypes are available. In another species, *G. simplex* (which includes synonyms *G. plantii* and *G. virescens* as well), the present author (Karihaloo 1985) recorded an octoploid, while earlier (Khoshoo 1956, Riley 1962, Narain 1977, Lemattre 1980) diploid and tetraploid cytotypes had been found. Obviously, polyploidy has played a prominent role in the evolution and distribution of this genus. Vegetatively multiplying plants like *Gloriosa* are known to accumulate a high frequency of polyploids and other chromosome variants. Sexual sterility, frequently observed in polyploids, does not impose a serious constraint on the survival of species which are not entirely dependent upon seeds for propagation.

Basikaryotypes of the 3 species bear broad similarity in having 3 long and 8 relatively short chromosomes. Significant discrepancies, however, exist in the morphology of some. The 11 basic chromosomes of diploid *G. superba* are all meta- or submetacentric. In tetraploid *G. carsonii* and octoploid *G. rothschildiana* on the other hand, 2-3 chromosomes are acrocentric or subtelocentric. Obviously, besides polyploidy, structural variations of chromosomes also have contributed to the evolution of the genus. Further, the absence of *G. superba* type genome in *G. carsonii* and *G. rothschildiana* indicates that *G. superba* has not been involved in the origin of either of the two polyploid species.

Four genomes constituting the somatic complement of *G. carsonii* resemble each other quite closely in both size and shape of chromosomes. Meiotic pairing behaviour,

where on an average only 1.85 quadrivalents were observed against a maximum possible of 11, indicates that the homology among the constituent genomes is not that close and the species is most likely a segmental allopolyploid. However, it has to be borne in mind that neither the morphology of chromosomes nor their pairing behaviour serve as true indices of the nature of polyploidy. Somatic chromosomes, according to Stebbins (1971), are mere shells which do not indicate the content within. Pairing behaviour, on the other hand, can be affected by a number of factors besides genetic homology: chromosome length (Stebbins 1950), arm ratio and rate of terminalization (Garber 1972), presence of multivalent suppressing genes (Riley and Chapman 1958), B chromosomes (Evans and Macefield 1973) and chiasma localization (Levan 1940). Further, selection over a period of several generations can significantly reduce the number of multivalents (Gilles and Randolph 1951, Aastveit 1968, Pal and Pandey 1982). Accordingly, the frequency of quadrivalents even in true autopolyploids varies over a broad range from species to species. In autotetraploids of *Triticum* spp. and *Zinnia elegans* exclusive bivalent pairing was reported by Avivi (1976) and Gupta and Koak (1976) respectively. Morrison and Rajhathy (1960) on the other hand, reported up to two-thirds quadrivalent pairing in the autotetraploids of a number of cereals and grasses. That chromosome size has a definite relation with quadrivalent pairing is evident in the meiosis of *G. carsonii*. The species has 3 long quadruplets, and it is these which associate into quadrivalents in the majority of cells.

Fertility of tetraploids depends largely, though not exclusively, upon the types of meiotic associations and their segregation pattern. Trivalents and univalents invariably result in irregular segregation and consequent unbalanced gametes. Bivalent pairing or quadrivalent pairing with 2:2 segregation ensures high gamete fertility. According to Rees and Jones (1977), if the number of chiasmata in a quadrivalent is 3 or more and these are located mainly in distal segments, only quadrivalents or bivalents are possible and trivalents and univalents are rare. This is true of *G. carsonii* where 90 IV studied in 50 MI cells have an average of 3.7 terminal and 0.4 interstitial chiasmata per quadrivalent. There are no trivalents or univalents and the anaphase segregation in 81% of the cells is regular 22:22. Expectedly, pollen stainability is quite high (87.1%).

Heteromorphicity in the karyotype of *G. rothschildiana* indicates that at least two or even three distinct genomes are involved in the origin of this octopolyploid. This contention is supported by the pattern of meiotic associations where just a few octovalent configurations are observed. This cytotype can be regarded as an auto-allopolyploid according to the classification of Stebbins (1950).

Comparison of chiasma frequency at MI reveals remarkable similarity in chromosome frequency among the three species (Table X). In *G. superba* and *G. carsonii*, even the distribution of chiasmata, whether terminal or interstitial, is almost the same. In *G. rothschildiana* the frequency of terminal chiasmata is lower while there is a proportionate increase in interstitial chiasmata. This discrepancy could be due to slower terminalization in higher multivalents of this species. Chin (1946), Dnyansagar and Sudhakaran (1970) and Laws (1967) reported reduction in chiasma frequency of polyploids as compared to diploids. Dhillon and Garber (1960) found varying reactions of chiasma frequency to polyploidization in species of *Collinsia*; in 2 species there was no change, in one there was increase, while in the other there was decrease.

SUMMARY

Karyotype and male meiosis were studied in 3 species of *Gloriosa*: *G. superba* ($2n = 22$), *G. carsonii* ($2n = 44$), and *G. rothschildiana* ($2n = 88$). The basic set of 11 chromosomes in the 3 species is comprised of 3 long and 8 relatively short elements. In *G. superba*, all the chromosomes range between meta- and submetacentric, whereas in *G. carsonii* and *G. rothschildiana*, 2-3 acrocentric or nearly telocentric chromosomes are also present. The average per cell metaphase I association is $10.89 \text{ II} + 0.21 \text{ I}$ in *G. superba*, $1.85 \text{ IV} + 18.30 \text{ II}$ in *G. carsonii*, and $0.06 \text{ VIII} + 0.52 \text{ VI} + 1.96 \text{ IV} + 0.02 \text{ III} + 37.20 \text{ II} + 2.10 \text{ I}$ in *G. rothschildiana*. Karyotype and nature of chromosome associations suggest *G. carsonii* to be a segmental allopolyploid and *G. rothschildiana* an auto-allopolyploid.

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TABLE I. KARYOMORPHOLOGY OF *G. SUPERBA*

Chromosome Number	Length (μ m)			Arm Ratio	Centromere
	short arm	long arm	total		
1, 2	3.8	3.8	7.6	1.00	M
3, 4	2.3	3.9	6.2	1.70	m
5, 6	2.9	2.9	5.8	1.00	M
7, 8	2.1	2.4	4.5	1.14	m
9, 10	2.0	2.4	4.4	1.20	m
11, 12	1.5	2.8	4.3	1.87	sm
13, 14	1.3	2.8	4.1	2.15	sm
15, 16	1.6	2.1	3.7	1.76	sm
17, 18	1.5	2.1	3.6	1.40	m
19, 20	1.5	1.5	3.0	1.00	M
21, 22	1.1	1.8	2.9	1.64	m

TABLE II. METAPHASE I ASSOCIATIONS IN *G. SUPERBA*

Sample Number	Associations		Number of Cells
	II	I	
1	11	0	76
2	10	2	9
Total	926	18	85
Average/cell	10.89	0.21	

TABLE III. KARYOMORPHOLOGY OF *G. CARSONII*

Chromosome Number	Length (μm)			Arm Ratio	Centromere
	short arm	long arm	total		
1-4	3.3	4.0	7.3	1.21	m
5-8	2.2	3.0	5.2	1.36	m
9-12	2.2	2.6	4.8	1.18	m
13-16	1.4	1.7	3.1	1.21	m
17-20	0.9	2.2	3.1	2.44	sm
21-24	1.1	2.0	3.1	1.82	m
25-28	1.1	1.5	2.6	1.36	m
29-32	0.3	2.0	2.3	6.67	st
33-36	0.3	1.7	2.0	5.67	st
37-40	0.8	1.1	1.9	1.38	m
41-44	0.6	1.3	1.9	2.17	sm

TABLE IV. METAPHASE I ASSOCIATIONS IN *G. CARSONII*

Sample Number	Associations		Number of Cells
	IV	II	
1	3	16	19
2	2	18	51
3	1	20	26
4	—	22	4
Total	185	1830	100
Average/cell	1.85	18.30	

TABLE VI. KARYOMORPHOLOGY OF *G. ROTHSCILDIANA*

Chromosome Number	Length (μm)			Arm Ratio	Centromere
	short arm	long arm	total		
1-6	2.4	2.8	5.2	1.17	m
9-16	1.8	2.4	4.2	1.33	n
17-24	1.8	2.0	3.8	1.11	m
25-32	1.0	1.5	2.5	1.50	m
33-40	0.8	1.6	2.4	2.00	sm
41-48	0.3	1.9	2.2	6.33	st
49-56	0.2	1.6	1.8	8.00	t
57-64	0.5	1.2	1.7	2.40	sm
65-72	0.8	0.8	1.6	1.00	M
73-80	0.6	0.7	1.3	1.17	m
81-82	0.8	1.0	1.8	1.25	m
83-86	0.2	0.9	1.1	4.50	st
87-88	0.1	0.6	0.7	6.00	st

TABLE V. ANAPHASE I DISTRIBUTION OF *G. CARSONII*

Sample Number	Distribution Pattern				No. of Cells	% Cells
1	22	:			22	56
2	21	:			23	8
3	20	:			24	1
4	21	:	1	:	22	2
5	21	:	2	:	21	1
6	21	+ 1/2	:	1/2 +	22	1

TABLE VII. METAPHASE I ASSOCIATIONS IN *G. ROTHSCILDIANA*

Sample Number	Associations						Number of Cells
	VIII	VI	IV	III	II	I	
1	1	—	3	—	33	2	1
2	1	—	2	—	36	—	1
3	1	—	2	—	35	2	1
4	—	2	4	—	30	—	1
5	—	2	2	—	34	—	1
6	—	2	1	—	35	2	2
7	—	1	4	—	33	—	2
8	—	1	4	—	32	2	1
9	—	1	3	—	34	2	2
10	—	1	2	—	37	—	2
11	—	1	2	—	36	2	1
12	—	1	2	—	35	4	1
13	—	1	1	1	36	3	1
14	—	1	1	—	39	—	2
15	—	1	1	—	38	2	3
16	—	1	1	—	37	4	1
17	—	1	—	—	39	4	1
18	—	1	—	—	40	2	1
19	—	—	5	—	33	2	1
20	—	—	4	—	35	2	1
21	—	—	4	—	34	4	1
22	—	—	3	—	38	—	1
23	—	—	2	—	40	—	1
24	—	—	2	—	39	2	7
25	—	—	2	—	38	4	4
26	—	—	2	—	37	6	2
27	—	—	1	—	42	—	1
28	—	—	1	—	41	2	3
29	—	—	1	—	40	4	2
30	—	—	—	—	43	2	1
Total	3	26	98	1	1860	105	50
Average/ cell	0.06	0.52	1.96	0.02	37.20	2.10	

TABLE VIII. ANAPHASE I DISTRIBUTION IN *G. ROTHSCHILDIANA*

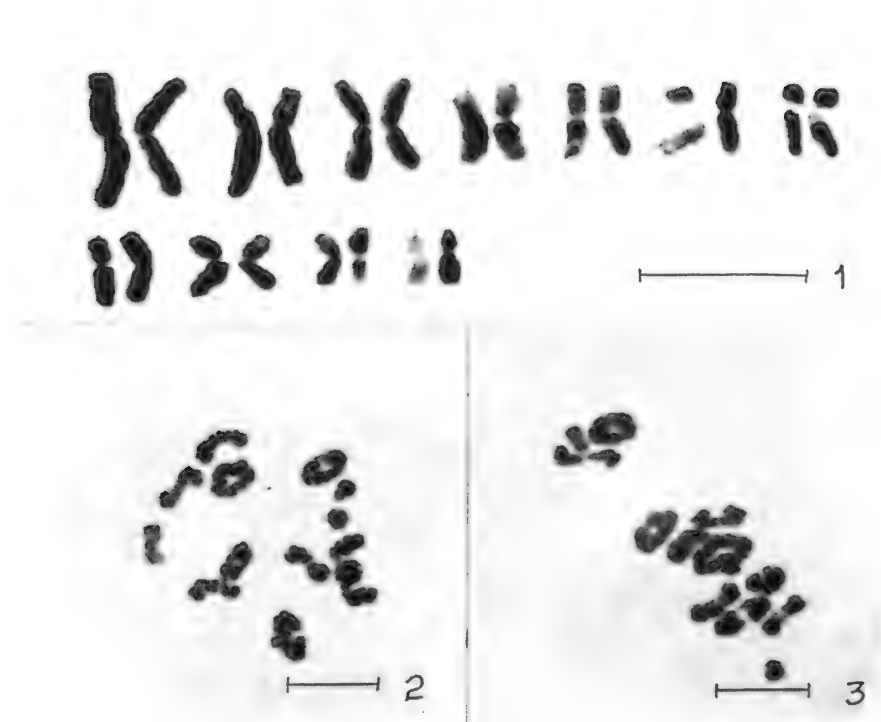
Sample Number	Distribution Pattern				Number of Cells	% Cells
1	44	:		44	8	34.8
2	46	:		42	1	4.4
3	44	:	1	43	6	26.1
4	45	:	1	42	1	4.4
5	43	:	1	43 + 2 (1/2)	1	4.4
6	43	:	2	43	1	4.4
7	44	:	2	42	1	4.4
8	45	:	4	39	1	4.4
9	44	:	1/2	43	2	8.7
10	47	:	1/2	40	1	4.4

TABLE IX. CHROMOSOME NUMBERS RECORDED IN THREE SPECIES OF *GLORIOSA*

Species	Chromosome Number	Authority
<i>G. superba</i>	22	Sato 1942
	22	Tjio 1948
	88	La Cour (cf. Fedorov 1969)
	22,44,66	Khoshoo 1956
	22,90	Sharma and Sharma 1961
	22	Mehra and Sachdeva 1976
	22	Narain 1977
	22	Lemattre 1980
<i>G. carsonii</i>	14	Sharma and Sharma 1961
	44	Narain 1977
	77	Lemattre 1980
<i>G. rothschildiana</i>	22	Tjio 1948
	66	La Cour (cf. Fedorov 1969)
	84	Sharma and Sharma 1961
	88	Narain 1977
	22,66,88	Lemattre 1980

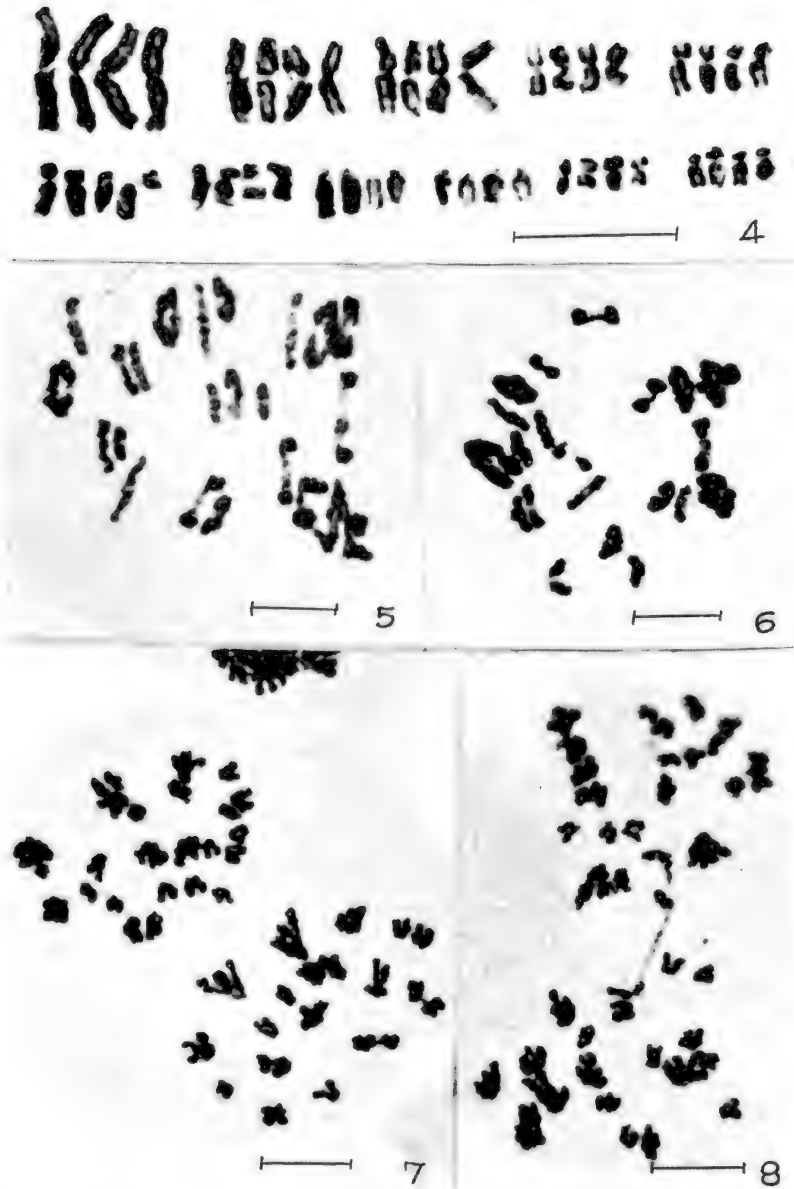
TABLE X. PER CHROMOSOME CHIASSMA FREQUENCY AT MI IN *GLORIOSA* SPECIES

Species	Chiasma Frequency		Total
	Terminal	Interstitial	
<i>G. superba</i>	0.53	0.13	0.66
<i>G. carsonii</i>	0.51	0.13	0.64
<i>G. rothschildiana</i>	0.42	0.22	0.64

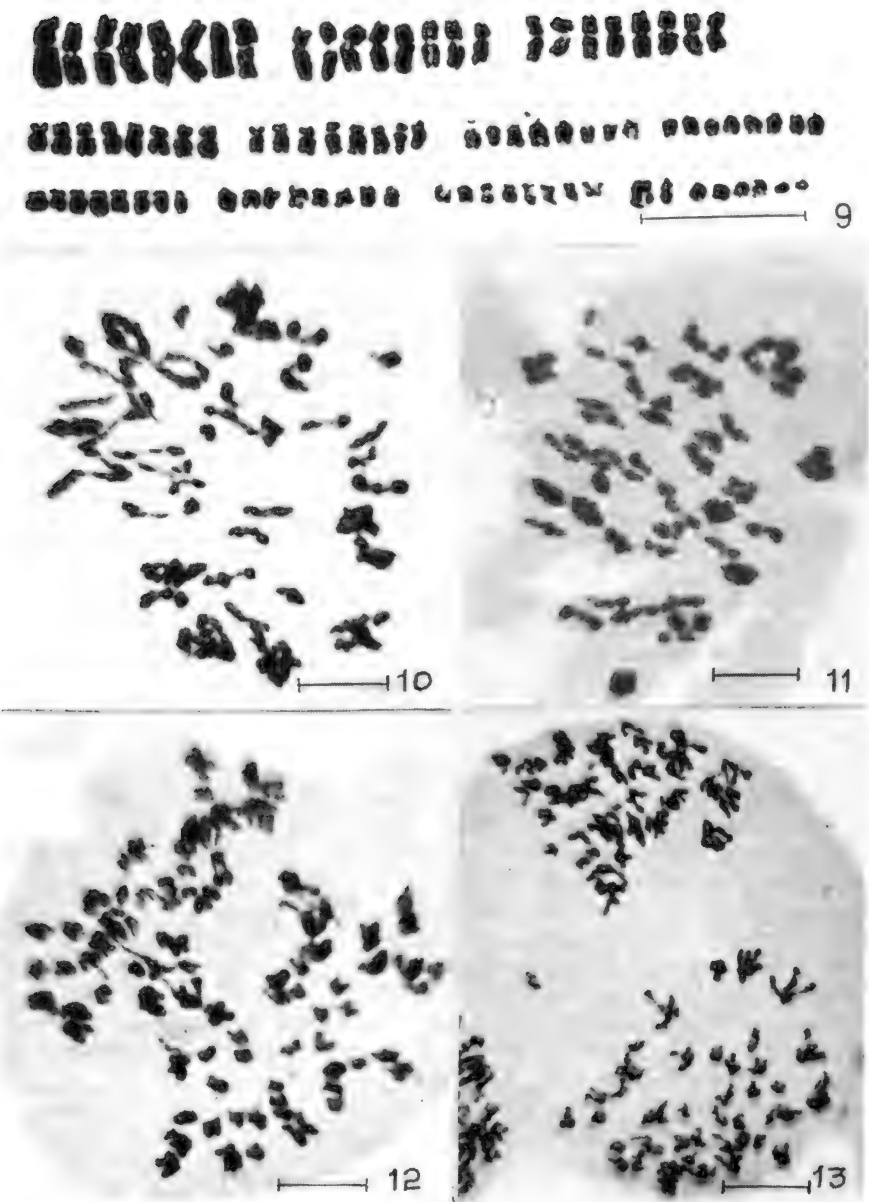


Figures 1-3: Cytology of *G. superba*. Figure 1. Karyiodiagram.

Figure 2. MI showing 11 II. Figure 3. MI showing 10 II + 2 I (scale = 10 μ m).



Figures 4-8. Cytology of *G. carsonii*. Figure 4. Karviogram. Figure 5. MI showing 2 IV + 18 II. Figure 6. MI showing 1 IV + 20 II. Figure 7. AI showing 23:21 distribution. Figure 8. AI showing 23:21 distribution and a bridge fragment configuration (scale = 10 μ m).



Figures 9-13: Cytology of *G. rothschildiana*
Figure 9. Karyodiagram. Figure 10. MI showing 1 VI + 4 IV + 33 II. Figure 11. MI showing 1 IV + 42 II. Figure 12. AI showing 42:46 distribution. Figure 13. AI showing 42:1:45 distribution (scale = 10 μ m).

EMMA SWETS—AN APPRECIATION

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One would never guess that half the space now occupied by a monstrous three story, block-long apartment building once was home to the premier bulb collection of Emma (Mrs. Leonard) Swets, "the bulb lady" of Riverside. Near the house were a few trees for home comfort and shelter for shade-loving plants, but most of the area was open to the sun for the tens of thousands of bulbs in great variety. I have never seen so many bulbs in a private garden.

By selection she developed strains of her own, particularly a splendid stand of *Alstroemeria* and a pure white *Lilium philippinense*. She was one of the first to produce a white *Amaryllis*. She also hybridized *Rhodophialia* producing a cross before it was recorded in *Herbertia* and called *R. X floryii*.

In the shade of a sapota tree she had a nice clump of *Haemanthus coccineus* and from seed raised a pink form. *Haemanthus punecius* var. *albiflos* in several forms, hybrid Belgian *Clivia* and *Laperousia laxa* (*cruenta*) flourished in a lathhouse.

Mrs. Swets was a *Crinum* enthusiast and had a large collection. These included 'Burbankii' obtained directly from Burbank, and 'White Queen' likely came from Henderson, Burbank's successor. She had enormous clumps of both of these, but because the flowers flag badly I paid little attention to them. From Mrs. Emma Foster of Covina, a charter member of this Society, she obtained *C. X digweedii* (*C. scabrum X C. americanum*) and *C. schmidtii* (These two I greatly admired and when the plants Emma gave me increased, I distributed them widely.).

Other *Crinums* of which there were sizable clumps included 'Twelve Apostles,' *C. asiaticum* 'Asiatica,' 'Peach Blow,' 'Cecil Houdyshel,' and 'Ellen Bosanquet.' Some such as *C. augustum* did not survive their first winter.

In *Herbertia* vol. 15, Mrs. Swets relates how it took her nearly 12 years to raise *Brunsvigia orientalis* from seed. The bulbs were enormous, nearly the size of a baby's head. Annually a fresh pair of leaves unusually broad but relatively short were laid down. For no apparent reason after blooming a number of years, they rotted.

In the early years she had a glasshouse Leonard had constructed for her, but since it was unheated it was not of much help in protecting its contents from the cold; however, this is where she raised seedlings of her white *Amaryllis* and *Haemanthus katherinae* and a very broad leaved *H. albiflos*.

Her row of *Lycoris radiata*, possibly 40 feet long and three feet wide, contained thousands of bulbs and when in bloom was spectacular. She also had *L. aurea* and others, but not in such numbers.

Other *Amaryllids* in the garden included *Brunsvigia*, *Hymenocallis*, *Ismene*, *Pancratium*, *Leucojum*, *Narcissus*, *Nerine*, *Sternbergia*, *Sprekelia*, *Chlidanthus*, *Zephyranthus*, *Amarerinum*, *Habranthus*, *Cyrtanthus*, *Manfreda*, *Amaryllis* and *Valotta*, before the bulb fly virtually eliminated the latter from this area. Without any danger of scraping the bottom of the barrel, I can recall 39 genera of bulbous, cormous, or tuberous plants which included a superior form of *Orchis bletilla*, a superb white *Watsonia* (not Mrs. Bullard's, but likely *W. ardernei*) a polyploid *Morea polys-*

tochia with flowers twice normal size, a beautiful clear yellow **Sparaxis**, the wonderfully fragrant **Gladiolus tristis**, and the striking **Ixia viridiflora** from time to time for it never remained long. An enormous colony of **Tulipa clusiana** was spectacular in spring as was an equally large colony of the French form of the white Roman hyacinth with its ravishing fragrance. Striking, principally because of its height approaching six feet, was **Albuca nelsoni**. Exquisite were all the **Cypella herbertii** in orange buff, the easiest and most numerous; **C. plumbea**, the closest to gray I have ever seen in a flower; and most beautiful of all, **C. plumbea** var. **pratensis**, in glorious blue.

One of Emma's great regrets was not obtaining seed-bearing **Lycoris radiata** when she could have. When she realized her loss, it was too late. Because of her wide experience in growing bulbous plants and her knowledge of the nomenclature, she was very influential on the garden scene. She was a devoted member of both local garden clubs and exhibited faithfully at the annual flower shows and since her entries frequently included items unfamiliar, they served as educational exhibits. She also was a member of the Inter-county Garden Club, the Gates Cactus Society, and of this Society for over 35 years.

Her acquaintanceship was wide. J. N. Giridlean was a good friend. For years she was a keen competitor for sweepstakes at the Los Angeles County Fair against Cecil Houdyshel (**Herbertia** vols. 5, 6, and 7). Dr. S. Stillman Berry and she were frequent judges at local flower shows. She exhibited at Fred Howard's spring bulb shows at Montebello (**Herbertia** vol. 7). She visited and exchanged plants with Hamilton Traub. She had a frequent visitor in Les Hannibal and enjoyed visits with James Melvin, a **Crinum** enthusiast with a splendid collection.

The example of her garden widened the horizon for all her horticultural friends. In **Herbertia** vol. 5 is a remarkable picture of some of California's horticultural greats of the 30's and 40's. The occasion is the presentation of the first William Herbert Medal to Arthington Worsley and includes Cecil and Ethel Houdyshel, N.M. James, and Emma Swets.

Mrs. Swets was born in East Prussia, Germany, and emigrated to the United States in 1910 at age 21 and found work as a nanny to the socially and intellectually prominent Alsop family in New York state. In 1912 she married Leonard Swets, an emigre of the Netherlands. They settled in Riverside where Leonard worked as a handyman at the famous Mission Inn. Anyone who has visited the Inn and observed its eclectic architecture where nothing is standard and everything custom made, one can understand the need for a handyman. To supplement income Emma undertook the provision of flowers for the dining room tables of the Inn at a penny per stem.

Many acquaintances thought of Emma as modest. Actually, she wasn't, she just wasn't forward. She was knowledgeable about her bulbs, their culture, and their nomenclature, and she knew it. She would help one with the pronunciation of **Velthemia** and **Verschaffiana** and squirm during garden lectures by the ill-informed. Her interest in plants never flagged. After Leonard's death she purchased a small automated glasshouse which was a joy and a solace.

For over 30 years we enjoyed one another's company. Most Saturday mornings she drove by to see my garden and this she did the Saturday before she passed away January 26, 1975, aged 86. She has left a great void her friends still feel. At a local garden club meeting when certain situations arise one will occasionally hear someone say, "Now if only Emma were here. . ."

ALSTROEMERIA CULTURE

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INTRODUCTION

The new **Alstroemeria** hybrid cultivars, most available from Europe (Table 1), are the result of years of interspecific breeding and x-ray irradiation to induce mutations. The majority of the new hybrid cultivars have originated from the van Staavern Company (The Netherlands) or from the Parigo Seed Company (England). Recently, two Dutch firms, the Wulfinghoff Company and Cor van Duyn Company have introduced several new and interesting **Alstroemeria** cultivars. In the United States, Sun Valley Bulb Farms of Myrtle Point, Oregon, have several cultivars available. Plants are normally leased to the greenhouse owner from the breeder; also, a royalty is assessed on the square footage in production. In the United States, the Fred Gloeckner Company (New York, New York) is the United States representative for van Staavern and Holland Park Products (Marietta, Georgia) are representatives for Cor van Duyn.

Alstroemeria species come in many different shades of violet, red, orange and yellow. The wide color range in the hybrids arises from the diverse color base found in the species. Natives have a wide range of habitats from the snowline of high Andes plateaus down through the western, coastal deserts of Chile. These different habitats result in specific requirements for flowering. The requirements for floral induction in the hybrids can be separated into two groups:

Group I. Species or cultivars which have a cold requirement and need a long day treatment for floral induction and initiation.

Group II. Species or cultivars which are prone to remain generative at high temperatures and under low light conditions.

PLANT CHARACTERISTICS

As the leaves on an **Alstroemeria** shoot unfold, they rotate 180° so that the upper surface becomes the under surface. The flowering stem consists of a whorl of flowering cymes; each bearing one to five sympodially arranged flower buds. The flowers open sequentially from base to tip with each flower on the cyme reaching anthesis as the next flower opens.

An **Alstroemeria** plant consists of a white fleshy rhizome which sympodially branches. Aerial shoots arise from this rhizome. The root system is moderately fibrous and becomes thickened. Each new aerial shoot arises from the first node of the preced-

ing flowering or vegetative shoot. Lateral rhizomes and storage roots develop from the second node. These lateral rhizomes give rise to additional aerial shoots.

These shoots can be either vegetative or generative (reproductive). Normally, shoots that have unfolded more than 30 leaves will not flower and are vegetative and are periodically removed. Once rhizomes are induced to flower by low temperatures and long days, all subsequent shoots will flower until subject to high soil temperatures.

FLOWER INDUCTION - TEMPERATURE

Flowers of *Alstroemeria* hybrids appear to be under the control of two mechanisms: a primary low temperature requirement and a secondary light (intensity and duration) requirement. As stated earlier, the temperature effect shows a group specificity with the "Group II" type requiring a shorter cold treatment—2 to 4 weeks of 4.5° C. (40° F.)—for floral induction and is able to tolerate a higher soil temperature. The variability between the two groups may be related to the parentage of the cultivars.

The Group II cultivar 'Orchid' has one parent (*A. violacea*) from the coastal deserts where the average winter temperature is 55° F. (12.7° C.). Conversely, the Group I cultivar 'Regina,' has a parent (*A. pelegriana*) from the highland forests where the average winter temperature is 52° F. (11° C.). The other parent, common to both hybrids, was *A. aurantica*, (now *A. aurea*) suggesting each species that contributes to a new hybrid may modify the flowering control mechanism.

Once beginning, plants will continue to produce flowering shoots until the soil temperature goes above 60° F. (15° C.) for 2 weeks. When "vernalized" plants are grown at soil temperatures above 70° F. (21° C.), plants will quickly cease flowering until they receive a cold treatment. When plants were grown at continuous 55° F. (12.7° C.) soil temperature, they continued to flower indefinitely regardless of air temperature, which exceeded 95° F. (35° C.) during the summer. Since the below ground rhizome must be kept near 55° F. for continued flowering, deep soil mulches, active soil cooling systems or misting the mulch to encourage evaporation will help maintain an appropriate soil temperature in conjunction with greenhouse evaporative air cooling.

FLOWER INITIATION - LIGHT

The other component that controls *Alstroemeria* flower initiation is light (duration and intensity). Once plants have perceived an adequate cold treatment, floral initiation was hastened by 13 hours of light obtained by using standard chrysanthemum lighting as a night interruption or day continuation. Lighting "non-vernalized" plants or those grown at 70° F. (21° C.) will not induce flowering. Photoperiods longer than 16 hours will not promote earlier flowering, but may decrease flower production. Lighting should occur about September 1 to April 15 at 45° North latitude (St. Paul, Minnesota). Check with your local weather bureau to determine the exact date when the day length drops below 13 hours.

Recent work in British Columbia has shown that high pressure sodium (HPS) lights for photoperiod control are more effective than incandescent in promoting flow-

ering. Flowering is most hastened when HPS is used in December or January. Total flower production is increased when HPS is used in conjunction with soil cooling. Since HPS both promoted earlier flowering and increased yield during the peak winter market period, the use of HPS may be economically feasible in certain areas of the country. In Minnesota, we do not feel such is economical.

Light intensity has also been shown to affect flower development. In northern Europe light intensity in the winter is low and flower bud abortion (blasting) is a problem. In Minnesota, we rarely observe bud blasting except where thinning is ignored and developing shoots are shaded by the thick canopy.

Bud blasting may be related to soil temperature which is too cool. Thus, in the northern U.S., light intensity may not be limiting to the degree that it influences bud development. But, low light intensities may decrease stem diameter. Since the number of cymes per stem is positively correlated with the stem diameter, alstroemeria plants should be grown with the maximum available light so that a optimal number of cymes per stem can be obtained.

PROPAGATION

Alstroemeria plants should be lifted and divided every second or third year, depending on the cultivar and plant growth characteristics. Since most **Alstroemeria** cultivars are patented, consult with your plant supplier to receive permission to divide plants. When an excessive number of thin, weak shoots are produced, the plants should be divided. About 1 to 2 weeks prior to dividing, plants should be hedged leaving only the youngest 6- to 8-inch shoots. This will stimulate new shoot growth. The pruning will also facilitate easier handling. When lifting well established plants after flowering decreases in late summer or early fall, care should be taken to dig deeply enough to remove the growing point as the rhizome can reach 12 to 14 inches (30 to 35cm). Excess soil should be removed from the clump to expose the individual rhizomes. Each new division should consist of a single rhizome with an undamaged, blunt growing point, new aerial shoots, and large fleshy storage roots.

The presence of these thickened storage roots is "critical" for the rapid reestablishment of the plants since the fibrous new roots will arise from these enlarged storage roots. Normally only the youngest 1 to 3 inches of the rhizome is kept with the older portion being discarded. These older rhizomes are of no value as the lateral rhizomes that may arise are often weak and lack vigor.

IMMEDIATELY after the rhizomes are divided, or new rhizomes are received, they should be planted. We have observed that when planting is delayed after division, reestablishment is considerably delayed. It is essential that pots, soil or ground beds be ready **BEFORE** plants are divided or received. If bare root plants must be stored, place rhizomes in moist peat moss and store at 35° F. (1.7° C.). Normally, extra plants are potted up to replace those that die or are not as vigorous as others in the production beds. It is expected that 5% to 25% will not survive bare root transplanting. To increase the survival rate, a fungicidal drench (8 oz./100 gal. water each of Lesan and Benlate) is recommended at the time of planting and again a month later if vigorous shoot and root growth is not observed. Excess watering will quickly rot recently transplanted rhizomes. After the initial watering with the fungicidal drench, spot water plants as they become dry. Over watering newly transplanted divisions is

the primary reason for plant loss. Grow the plants at 60° F. (15° C.) until they become well established (4 to 8 weeks), before lowering the temperatures to 40° F. (4.5° C.).

CULTURAL REQUIREMENTS

When new growth commences, numerous vegetative shoots will form. Removing weak vegetative shoots has been shown to increase flower production. Shoot removal acts as a "pinch" and encourages growth of the lateral rhizomes. Vegetative shoot thinning should occur continuously—we recommend every 3 to 4 weeks—and at one time no more than 25% of the blind vegetative shoots should be removed. When excessive thinning occurs, the returning flowering (generative) shoots may exhibit a phenomenon referred to as "short shoot." The "short shoot" problem normally will persist until plants revert to a vegetative stage.

Stems may be cut at the soil line or a quick upward pull will cleanly remove the shoot from the rhizome. Care should be exercised when pulling stems from young or poorly rooted plants since the rhizome may be uprooted or torn loose from the soil. During late summer production it may be preferable to cut flowering shoots since the lateral rhizome is frequently removed when stems are harvested.

Alstroemerias should be given approximately 1.5 to 2 square feet per plant. At this spacing, yield is optimized while costs of plants and greenhouse space are minimized. Vigorous growing cultivars which are to remain in production for 2 to 3 years should be planted at 2 square feet per plant; less vigorous cultivars should be planted at 1.5 square feet per plant. A strong 4 to 6 layer support system is recommended since some alstroemeria cultivars can grow to 6 to 8-feet tall. The medium used can be any good well-drained greenhouse soil, gravel, or scoria. Ground beds are preferable to raised beds or pots since soil temperature does not fluctuate as rapidly.

Alstroemeria cultivars are heavy feeders especially as the flowering shoots are developing. Research has shown that greater flower production is obtained when the nitrogen to potassium feed ratio is 1:2. Ammoniacal forms of nitrogen fertilizer should be avoided, as at 55° F. (13° C.) growing temperatures, ammonia is not readily converted to nitrate. Application of minor nutrients may be required to maintain optimum levels within the plant.

Insects and diseases are not a serious problem on **Alstroemeria** hybrids. Whitefly and aphids may appear during warm weather. **Alstroemeria** foliage is very tender; insecticide sprays should be applied early in the morning or on overcast days to prevent foliar burn.

The only reported soilborne disease to seriously affect alstroemeria shoots is *Rhizoctonia*. Recently transplanted rhizomes are most susceptible to *Rhizoctonia*. Application of Benlate (8 oz./100 gallons) after planting and every 6-8 weeks will normally maintain control. *Botrytis* can be a problem on leaves and young shoots if inadequate thinning has occurred. Regular thinning and good air movement will easily control *Botrytis*.

We have observed leaf mottling and verified this as a virus infection. The virus induced symptoms of malformed leaves tends to be temperature sensitive with symptoms disappearing at 55° F. (13° C.) and reappearing at 70° F. (21° C.). Rogue virus infected plants to reduce the spread of the virus. There are currently efforts underway in Europe to produce virus free plants.

POSTHARVEST

Flower size is largest when one or two of the primary flowers are allowed to open prior to harvest. Once the pollen has begun to dehisce, maximum flower size has been attained. After harvest, place shoots in good clean water in a 35° F. (1.7° C.) cooler for at least 24 hours. We have seen little response to any commercial floral preservatives. The white basal portion of the stem should be removed to maximize water uptake. There is no benefit in removing leaves although some growers will remove them to facilitate handling. Flowers can be dry stored at 35° F. (1.7° C.) for up to 5 days; although quality of the primary flower can be seriously reduced.

There are currently two methods for marketing *Alstroemeria*. One simply places 10 to 12 flower stems in a bunch. The more desirable method places the stems into 3 grades. Grade 1 has 10 stems with 5 or more cymes per 36 inches (90cm) + stem length; Grade 2, 3 to 4 cymes per 24 inches (60cm) + stem length; and Grade 3, less than 3 cymes per 12 inches (30cm) + stem length. Stems are downgraded for crooked or damaged stems or poor foliage.

TABLE 1. SOME ALSTROEMERIA CULTIVARS BY COLOR.

Red-Lavender		
Bronze		
Harmony (S)	Carmen (P)	Butterfly (W)
	Fanfare (W)	Jubilee (S)
	King Cardinal (S)	Lilac Glory (C)
Orange	Red Sunset (S)	Luciana (S)
Campfire (S)	Red Surprise (S)	Orlando (C)
Harlequin (W)	Result (W)	Ornate (C)
Orange Beauty (S)	Valiant (W)	Ostara (C)
Orchid Florin (P)	Tango (S)	
Sunrise (C)		
Westlant (C)		
Pink	Red-Purple	Salmon/White
Appleblossom (S)	Marina (P)	Atlas (S)
Capitol (W)	Purple Joy (C)	Mona Lisa (S)
Jacqueline (C)	Sunstar (C)	
Olympie (C)	Valeria (C)	
Pink Panther (C)		
Pink Perfection (P)	Yellow	
Pink Triumph (S)	Canaria (S)	
Regina (S)	Eleanor (W)	
Rita (S)	Friendship (W)	
Rosario (V)	Orchid (S)	
Rosali Staliro (S)	Rio (W)	
Rosello (S)	White Wings (S)	
Rosita (S) (C)	Yellow King (S)	
Rosy Wings (C)	Yellow Tiger (S)	
Trident (W)	Zebra (S)	

P - Parigo; Spalding, England

S - M.C. van Staavern; Aalsmeer, The Netherlands

W - A. Wulfinghoff; Rijnsijk, The Netherlands

C - Cor van Duyn; Rijnsburg, The Netherlands

V - Sun Valley Farms; Myrtle Point, OR, USA

CONSERVATION PROBLEMS IN THE **AMARYLLIDACEAE**

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The general plight of plant species has been the focus of numerous authors in recent years (Koopowitz & Kaye 1983; Raven 1976; Ayensu *et al.* 1984; Huxley 1984). It is generally conceded that within the next fifty years between 10 and 25 percent of all higher plant species are in danger of extinction. Exact data are difficult to come by, but the many recent Red Data Books for plants attest to the problem. The major cause of plant endangerment centers upon the human population explosion with its attendant habitat destruction. Several options are available to minimize the numbers and rates of plant species attrition. These range from setting up preserves to establishing cryogenic gene banking.

At the University of California Arboretum at Irvine we maintain a conservation collection of petaloid monocots. The current focus of the collection is on the African species from the families **Amaryllidaceae**, **Iridaceae** and **Liliaceae**. The collection contains not only living plants but also cryogenic pollen and seed banks. Of the three families, the **Amaryllidaceae** appear to be the most difficult with regards to maintaining a viable conservation collection.

The **Amaryllidaceae** is a small, uniform group of petaloid monocotyledonous species that are allied to the **Liliaceae**. Few of the species have any agricultural importance but as a whole the family has supplied many desirable ornamentals such as: **Crinum**, **Cyrtanthus**, **Hippeastrum**, **Lycoris**, **Narcissus**, **Nerine** and **Scadoxus**. Not only are many hybrids created and grown, but the wild species are eagerly sought as collector's items.

Although the exact number of species and genera in the **Amaryllidaceae** is not known, a conservative estimate would be 60 genera and 1,000 species (Dyer 1976). Several families formerly included within the **Amaryllidaceae** have been separated from it. These include the **Agavaceae**, **Alstroemariaceae**, and **Haemadoraceae**. While the distribution of genera is worldwide, one can recognize two major centers of distribution (Traub 1963): South America, ranging from the tropical lowlands into the more temperate Andes; Southern Africa, extending from the western Cape northward into the tropics. In addition, certain genera such as **Narcissus** have centers of diversity in the Iberian Peninsula (Grey-Wilson and Mathew 1981) while other genera such as **Crinum** occur dispersed in a cosmopolitan tropical and sub-tropical band (Hannibal 1972).

The **Amaryllidaceae** as a whole is unusual—from the point of species conservation—because it possesses several distinctive features that make it particularly vulnerable. These are factors that arise from the biology of the organisms and quite different from the man-made problems such as habitat destruction which are at the root of the problem. None is unique to the amaryllids, but it is the combination of so many that will make conservation difficult. Biological factors that impede conservation efforts in the group include long generation time, incompatibility factors, fleshy seeds, disease susceptibility and specialized cultural needs.

GENERATION TIME

While there are some species such as *Cyrtanthus mackenii* that can cycle through a single generation within a year, most of the amaryllids grown at the UCI Arboretum tend to have fairly long generation times. Some typical times taken to produce flowers from seeds are:

<i>Amaryllis belladonna</i>	> 6 years
<i>Brunsvigia litorallis</i>	= 6 years
<i>Brunsvigia minor</i>	= 5 years
<i>Brunsvigia gregoriana</i>	= 7 years
<i>Boöphane disticha</i>	= 8 years
<i>Crinum macowanii</i>	> 9 years
<i>Cyrtanthus herrei</i>	= 8 years
<i>Cyrtanthus obliquus</i>	> 5 years
<i>Haemanthus pubescens</i>	= 3 years
<i>Haemanthus sanguineus</i>	= 3 years
<i>Nerine masonorum</i>	= 3 years
<i>Narcissus bulbocodium</i>	= 3 years
<i>Narcissus triandrus</i>	= 3 years

These values are not unusual considering that hybrid daffodils can take seven or eight years to flower from seed and *Clivia* hybrids, even longer.

On an average, the shortest generation can usually be expected is three years (given optimal growing conditions). Admittedly, this is less than required by many trees; nevertheless, for small flowering plants it is a considerable investment in time and effort to raise a species from seed to flowering. Using sexual reproduction it can take a long time to generate a population of mature plants.

The actual longevity of many amaryllids is much longer than the minimum times taken to reach flowering. Certainly, clumps of some amaryllids in cultivation have survived through many decades. In the field, the immense bulbs of *Brunsvigia* suggest they might be well over a century in age. Compared to the lifespan of the plants, the time taken to reach sexual maturity is short. However, in terms of conservation projects, such spans are very long. It is almost impossible to obtain funds to resurrect populations if the time needed for financial commitment is longer than 3 years.

INCOMPATIBILITY FACTORS

A number of amaryllid species are self-sterile. These include species in the African genera *Boöphane*, *Brunsvigia*, *Clivia*, *Cyrtanthus* and the American genera *Eucharis*, *Euchrosia*, *Hippeastrum*, *Rhodophiala* and *Urceolina*. Not all species within a genus are necessarily self-sterile, but data on the ability to produce viable seed after self-fertilization has not been systematically collected or collated. In addition, some species will not set seed even if pollinated with fresh pollen from different but related clones. This is referred to as sibling-sterility. Experiences at the Arboretum with three different amaryllids is presented to convey some of the problems involving fertility encountered in trying to maintain and increase captive populations.

Boöphane disticha is a widespread and variable species from Southern Africa growing in a variety of conditions ranging from winter to summer rainfall. It is not a threatened species and is still quite common. Plants grown from seed collected from a winter growing plant eventually flowered after 8 years. The flowers were white; gradually turning pinkish. This is an unusual color phase. Most plants have flowers that are a pinkish-brick color. Inflorescences from three clones were self-pollinated and their pollen was used to cross-pollinate three other clones. Only the cross-pollinated clones set seed. This is a species that appears to be only self-sterile.

Brunsvigia litorallis is an endangered species from the coast of Southern Africa. The Arboretum at UCI possesses nine mature flowering plants all obtained from an initial seed sample sent from South Africa. The plants flower regularly but will not set seed even if pollinated by any of the other eight individuals. All plants, however, will produce fertile seed if pollinated from other closely related species or genera including **Amaryllis belladonna**, other **Brunsvigia** species—or even **Nerine** hybrids. Clearly the plants are capable of producing viable seed. It is surmised that the original seed batch was collected from the same inflorescence with the siblings inheriting similar incompatibility factors. To avoid this problem it is useful to know both the immediate supplier of the material and (if plants have changed hands several times) the natural source.

Cyrtanthus obliquus is also self-sterile. Six plants were grown from seed to flowering. Individual clones tended to flower over a several month period and no two clones ever flowered simultaneously. The timing problem was solved by freezing pollen (Koopowitz *et al.* 1984) from one clone and pollinating a second clone the following year. The cross was successful and several hundred seedlings resulted. Unfortunately, the original six clones became heavily virused and were discarded. This was before it was realized sibling plants might be partially or totally sibling-sterile. It is possible that a dead-end has been reached in this generation, and new and unrelated stock will have to be retrieved in order to continue the captive population. However, it will still be several years before the seedlings flower and we can assess their interclonal fertility.

The obligatory outbreeding found in many members of this family is an adaptation against inbreeding. As breeding populations decrease in size a point is reached where related individuals will mate with each other. When this happens, the probability increases that deleterious or lethal genes will be expressed. The phenomenon is known as inbreeding depression (Briggs and Knowles 1967) and is common in both animals and plants. This subject has not been examined in any detail for the **Amaryllidaceae**. Common expressions of inbreeding depression include decreased vigor, shortened life spans, and decreases in fecundity. In addition, there is a decrease in the total genetic variability of the population. By chance, some individuals can be produced that have lost all of the deleterious and lethal genes. Such individuals may be quite vigorous but genetically uniform. This is fairly common in domesticated strains of plants. Because of the long life spans, inbreeding depression may not be noticeable—but could be observed if plants are compared to older clones still in cultivation (provided these older clones are not virused).

In order to avoid inbreeding depression it has been suggested that a minimum of 500 different and unrelated clones should be maintained in a randomly breeding population (Frankel and Soule 1981).

FLESHY SEEDS

Most plants produce seeds that go through a dormant phase, even if that phase is relatively short. During that time the seed can be partially dried and then frozen; placing the seed into a form of cryptobiosis or suspended animation (Harrington 1972). This is the basis for most cryogenic seed banks that are involved in storing plant germplasm. However, many of the amaryllids produce very large fleshy seeds that often start to germinate while the seeds are still in the pod. These seeds cannot be dried without killing the embryos. However, some amaryllids have drier seeds; usually thinner and with a black testa. Seed of *Cyrtanthus*, which is of this type, have been successfully frozen and retrieved. Genera with fleshy seeds include *Amaryllis*, *Brunsvigia*, *Crinum*, *Hymenocallis*, and *Nerine*. Less fleshy seeds are found in *Cyrtanthus*, *Ha-branthus*, *Hippeastrum* and *Zephyranthes*. Whether or not genera other than *Cyrtanthus* can be stored cryobiotically is still to be determined.

There is the possibility that embryos could be excised from fleshy seeds—then processed and frozen using sterile tissue culture techniques. These seeds could be placed into cryogenic banks, but the process would be far more involved and expensive than normal seed banking.

DISEASE SUSCEPTIBILITY

One of the major problems in maintaining a living plant collection is controlling the spread of virus diseases. It is difficult to find a collection of amaryllid species where one can unequivocally demonstrate virus free stock. As with many other "cultivated" crops, amaryllids are rife with a variety of viral infections. In certain commonly grown ornamental plants such as *Narcissus* and *Hippeastrum*, it is almost impossible to obtain clean stock, or accomplishing that, to control the spread of insect vectors over extended periods of time. Not only are natural vectors a problem, but it is easy to transfer the virus to clean plants during repotting and dividing unless scrupulous hygiene is maintained. Attention must be paid to disinfecting cutting tools when used for different plants.

Although common in cultivation, virus is rarely encountered in the field. Increased agriculture in parts of South America is rumored to be causing corn mosaic virus in wild plant populations of *Hippeastrum*, but knowledgeable collectors assert they do not find such infected wild plants (K. Robertson, personal communication). We have never found obviously virus infected plants of the *Amaryllidaceae* in the field in Africa. It is possible to "cleanse" the virus by a variety of techniques but these are time consuming and expensive. Until inexpensive and simple antiviral agents are available to combat virus in amaryllids, these diseases will pose a conservation problem.

SPECIALIZED CULTURAL NEEDS

The majority of species in the *Amaryllidaceae* are tender or tropical subjects and must be grown under protection in most of the temperate countries. This means that it is expensive to maintain populations of species that represent a reasonable faecsimile of the gene pool available within the species. The space requirements for such a collection are substantial. If we assume that 500 randomly selected individual plants would give a meaningful representation of the gene pool variation (Frankel and Soule 1981)—a complete collection for a genus like *Cyrtanthus* with about 50 species would

need 25,000 containers. The average container size in that genus needs to be approximately 8 liters and occupies an area of about 225 cm². For the entire collection, one would need a minimum space of approximately 6×10^4 M² (6000 M²).

Not only is space a problem but diversity of cultural requirements often makes effective use of the space difficult. Within the genus *Cyrtanthus*, adaptations range from heat-tolerant desert forms such as *C. herrei*, to "cool" high altitude species such as *C. erubescens*. Some grow in harsh sunlight like *C. smithii*; while *C. sanguineus* is a moist forest form that prefers light shade. Many of the species will not flower unless the veldt in which they live has been burned. Conversely, *C. spiralis*, are notoriously difficult to maintain in cultivation unless one matches their seasonal requirements. *C. capensis* must be kept absolutely dry during its dormant season in the winter and spring. Other species such as *C. mackenii* appear to have no dormancy requirements at all but will grow and flower year-round in cultivation.

CONCLUSION

The total numbers of amaryllids presently at risk in the world is not known. Southern Africa possesses about 22 percent of the world's amaryllid species; of these, 66 species in some 13 genera fall into various categories of endangerment (Hall *et al.* 1980). This amounts to 30 percent of Southern African species. However, because most amaryllids are tropical and from areas with even higher levels of endangerment—that a 30 percent figure may be too conservative. With the array of problems posed by the *Amaryllidaceae*, it's essential that those interested in this group and its immense horticultural potential conserve as much of this heritage as possible. Many of the genera have hardly been examined from a horticultural point of view. Those species that have been used horticulturally have produced such outstanding ornamental material that one could reasonably expect similar results with many other taxa. We impoverish both ourselves and our children if we neglect to care for those resources entrusted to us now!

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UPDATE ON **EUPHARIS** CHROMOSOME CYTOLOGY

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In the 1984 **Herbertia** (Meerow, 1984), I reported some of my early work on **Eupharis** Planch. chromosome cytology. Having now largely completed an exhaustive survey of the genus for my forthcoming monograph, some errors in that early work require correction.

The most common somatic chromosome number in the genus is $2n = 46$, not 44, as I first reported. Pretreatment with 10ppm o-isopropyl-N-phenylcarbamate (Storey & Mann, 1967) in place of hydroxyquinoline or colchicine, has resulted in enormous improvement in the resolution of mitotic metaphase configurations of root tips. Two small chromosomes are easily lost when the cell membrane is broken (often necessary to fully spread the large number of chromosomes), or else obscured when the chromosomes are insufficiently condensed. Mookerjee (1955), who reported $2n = 44$ for **Eupharis**, probably encountered the same problem. **Urceolina** Reich. also is characterized by $2n = 46$. Full details and representative karyotypes will be found in Meerow (1986).

The implications of this are important in relation to the systematics of Neotropical genera of subfamily Pancratiodeae Meerow (1986). $2n = 46$ is the most common somatic chromosome number found in all Neotropical tribes of the subfamily (Di Fulvio, 1973; Flory, 1977; Williams, 1981; Meerow, 1985a, 1985b, unpubl. data), supporting the concept of monophyly of the subfamily. It limits, however, the utility of chromosome shape or karyotype analysis in tracing putative phylogenies within subfamily Pancratiodeae, as chromosome morphology of the different genera does not reveal enormous differences. A somatic chromosome number of $2n = 46$, conceivably evolved from an ancestor with $2n = 22$ [cf. **Pancratium** L. (Ponnamma, 1978)] through chromosomal duplication or fragmentation, followed by doubling of the entire genome (Sato, 1938; Lakshmi, 1978). This has remained a relatively stable characteristic of these genera, with the notable exception of some **Hymenocallis** Salisb. (Flory, 1976) and the genus **Hieronimiella** Pax (Di Fulvio, 1973, 1975). As has been described for the genera **Crinum** L. (Raina, 1978) and **Hippeastrum** Herb. (Naranjo & Andrada, 1975), mutation, rather than more obvious chromosome structural rearrangement, has probably been more important in directing the course of evolution in subfamily Pancratiodeae.

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BESCHORNERIA CALCICOLA (AGAVACEAE)
A NEW SPECIES FROM MEXICO

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SUMMARY

A new species, **Beschorneria calcicola** García-Mendoza, is described from Oaxaca and Puebla. Its distribution, habitat, and affinities are briefly discussed, and specimen citations are given.

INTRODUCTION

Beschorneria Kunth, is a small genus endemic to Mexico. In the course of taxonomic studies on the genus, I collected material that represents a new species.

Beschorneria calcicola García-Mendoza, species nova (Figures 1, 2, 3 & 4).

Plantae perennes, acaules; folia glauca linearia, erectiuscula; inflorescentia racemosa bracteolata, bracteis pedicellis aequantibus vel brevioribus; flores roseoli in fasciculo 1-3 dispositi, apice albo, ovarium et perianthum puberulum; capsula subglobosa.

Plants perennial, acaulescent, in groups 10-15 from a short rhizome with fibrous roots.

Leaves in a dense rosette, linear, 30-50cm long, 0.3-0.6cm broad, conduplicate, rigid, erect or sometimes more or less recurved, carinate abaxially, the base triangular, 4-6cm long, 1.5-2.5cm broad, yellowish, the margin denticulate, the surface somewhat rough adaxially, scabrous abaxially, glaucous in living plants, drying greenish yellow.

Inflorescence racemose, 115-230cm tall, the peduncle 0.5-0.8cm in diameter, 80-100cm long, pinkish or yellowish, bracteolate with 7-13 sterile bracts 1.6-2cm long, 0.3-0.7cm broad, pink in color, with 10-17 floriferous bracts 0.6-1.2cm long, 0.3-0.6cm broad, pinkish to scarious, the bractlets to 0.5cm long, caducous. Flowers 16-30 per inflorescence, in fascicles of 1-2(-3) flowers, each bearing a bracteole at its base; pedicels 0.7-2cm long, generally longer than the bracteoles, articulate at the apex, glabrescent.

Flowers (3.5-) 4-5cm long including the inferior ovary, 0.6-1cm broad, pendulous, tubular, only the apices spreading; tepals 6, connivent in two equal series, the external segments linear (2-) 2.5-3.3cm long, 0.2-0.3cm broad, swollen at the base, the internal segments linear-spathulate, 0.4-0.5cm broad, with a dorsal midrib, externally puberulent, papillose within, tepals externally pink or yellowish, white at the apex and within; stamens 6, equal to or slightly shorter than the perianth, the fila-



Beschorneria calicicola García-Mendoza (720).

Figure 1. *B. calicicola* in habitat.



Figure 2. Group of sterile plants.



Figure 3. Inflorescence with pink flowers.



Figure 4. Flowers and fruits.

ments subulate, dilated at the base for 1-1.5mm, papillose, white, the anthers linear-oblong, 0.3-0.6cm long, 0.1-0.3cm broad, pale green; ovary inferior, oblong to subglobose 1.3-2cm long, 0.2-0.4cm broad, 6-angled, puberulous, pinkish or yellowish, style exceeding the stamens, sometimes exceeding the tepals by 1-3mm, papillose, white, dilated and trisulcate at the base, with one nectary per sulcus; stigma capitate, 0.8-1.2mm in diameter, sometime ciliate and papillose.

Capsule loculicidal, erect, subglobose 2-2.8cm long, 1.5-1.8cm broad, pinkish when young, the perianth persistent, the pedicels thickened, 2-3mm in diameter.

Seeds 90-130 per capsule, plano-convex, 0.5-0.7cm long, 0.4-0.5cm broad, black and shiny when fertile, dull and whitish when sterile.

TYPE: MEXICO: OAXACA, Distrito de Teposcolula, 3km al Oeste de Tamazulapan, camino a Chilapa; ladera caliza con matorral esclerófilo, alt. 2330m, 8-VIII-1981 (fl., fr.), *A. García-Mendoza* y *D. Lorence* 720 (Holotype: MEXU; Isotypes: MEXU, ENCB).

ADDITIONAL SPECIMENS EXAMINED: OAXACA, Distrito de Teposcolula, 5km al Norte de Tamazulapan, alt. 2400m, 25-VIII-1983 (fl., fr.), *A. García-Mendoza* 1230 (MEXU); 3km al Oeste de Tamazulapan, camino a Chilapa, alt. 2000m, 7-VI-1985 (fl.), *A. García-Mendoza* y *R. Torres* 1420 (MEXU). PUEBLA: Municipio de Chapulco, 10km al NE de Azumbilla, carretera a Esperanza, alt. 2050m, 24-VI-1985 (fl.), *P. Tenorio*, *O. Dorado* y *A. Salinas* 9060 (MEXU).

DISTRIBUTION AND HABITAT

The new species is restricted to northwestern Oaxaca and southeastern Puebla, in the upper vegetational limits of the Tehuacán Valley Floristic Province. The climate is dry with summer rains (BS). It occurs at 1900-2400m altitude and appears to be restricted to soils derived from calcareous rocks. It often grows in association with *Schoenocaulon* sp. in Sclerophyllous Matorral Formations comprised of the following species: *Actinocheila potentillifolia*, *Aralia humilis*, *Dasyllirion* sp., *Desmodium orbiculare*, *Fraxinus pringlei*, *Garrya ovata*, *Lindleya mespiloides*, *Mortonia diffusa*, *Neopringlea viscosa*, *Quercus* sp., *Rhus chondroloma*, *Pithecellobium elachystophyllum*, *Perymenium discolor* and *Thryallis glauca*. *Beschorneria calcicola* flowers from May through August or September.

AFFINITIES

Beschorneria calcicola is most closely allied to *B. tubiflora* (Kunth & Bouché) Kunth, but differs in its linear carinate, glaucous, conduplicate leaves, racemose inflorescence with fewer flowers, and the pink or yellow, externally puberulous flowers. In addition, *B. calcicola* is restricted to matorral vegetation over limestone substrate in the southern part of Tehuacán-Cuicatlán Valley of Puebla and Oaxaca, whereas *B. tubiflora* occurs in *Quercus-Pinus* forest in San Luis Potosí.

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THE DISTRIBUTION OF THE GENUS **LILIUM** WITH REFERENCE TO ITS EVOLUTION

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The genus **Lilium**, a member of the Liliaceae, consists primarily of diploid species with $x=12$ (Noda, 1977). Lilies are distributed in an irregular, circumboreal band in the temperate region of the northern hemisphere; primarily between the 10th and 60th parallel, similar to **Primula** and **Gentiana** (Stern, 1938; Stoker, 1933).

The earliest attempt to map the species range was accomplished by Elwes (1880). The distribution boundaries were, in many cases, incorrect. Wilson (1925), excluded distributions in his work, "The Lilies of eastern Asia." Stern (1938), summarized the distribution, but made no mention of lilies in the USSR and ignored the entire range of several species.

Until Comber (1949), **Lilium** was solely classified by flower shape and position. Comber based his classification on seed germination, nectary position, and 13 other characteristics. Comber's work commenced an understanding of phenomena, in addition to classical taxonomic designations, that enabled greater understanding of lily evolution. Lighty (1962), published the most exhaustive classification system to date relating to distribution. It was the first work since the 1880 publication by Elwes to do a comprehensive geographical study, as well as include taxonomic traits and crossing coefficients.

As a group, **Lilium** range in Asia from Kamchatka Island (56° N.) and lower Yenisei in central Siberia (68° N.) to Luzon (17° N.) and India (11° N.) in the south. Longitudinally, they extend from Europe (20° W.) and Asia to Kamchatka (158° E.) and from Vancouver Island eastward to Nova Scotia in the New World. None are native to the British Isles or central Asia. The species are naturally classified as European, West Asiatic, East Asiatic, and American.

The range of the northernmost lily, **L. martagon** var. **pilosiusculum** Freyn., coincides with the northern boundary of forestland in the USSR (Baranova, 1966). Northward, bulbs would not have the winter protection afforded by the forest undergrowth.

The number of species of **Lilium** closely approximates 100 (Baranova, 1966; Fahreniadi, 1968; Lighty, 1962). North America has 30 species primarily confined to the oceanic and coastal regions. Europe has 10 species; the Caucasus region being one of the European centers of formation. Eight species in this region are endemic. The greatest diversity of species—more than 50%—are found in eastern Asia (Figure 1) (Shimizu, 1984) where approximately 60 species are native, the majority of them endemic. Three closely related genera are also endemic to the region: **Cardiocrinum**, **Notholirion** and **Nomocharis**. Researchers agree that the region of Manchuria, Japan and Korea is the center of origin for the genus **Lilium** (Lighty, 1970).

Stoker (1933) affirmed that plants of temperate regions of the Northern Hemi-

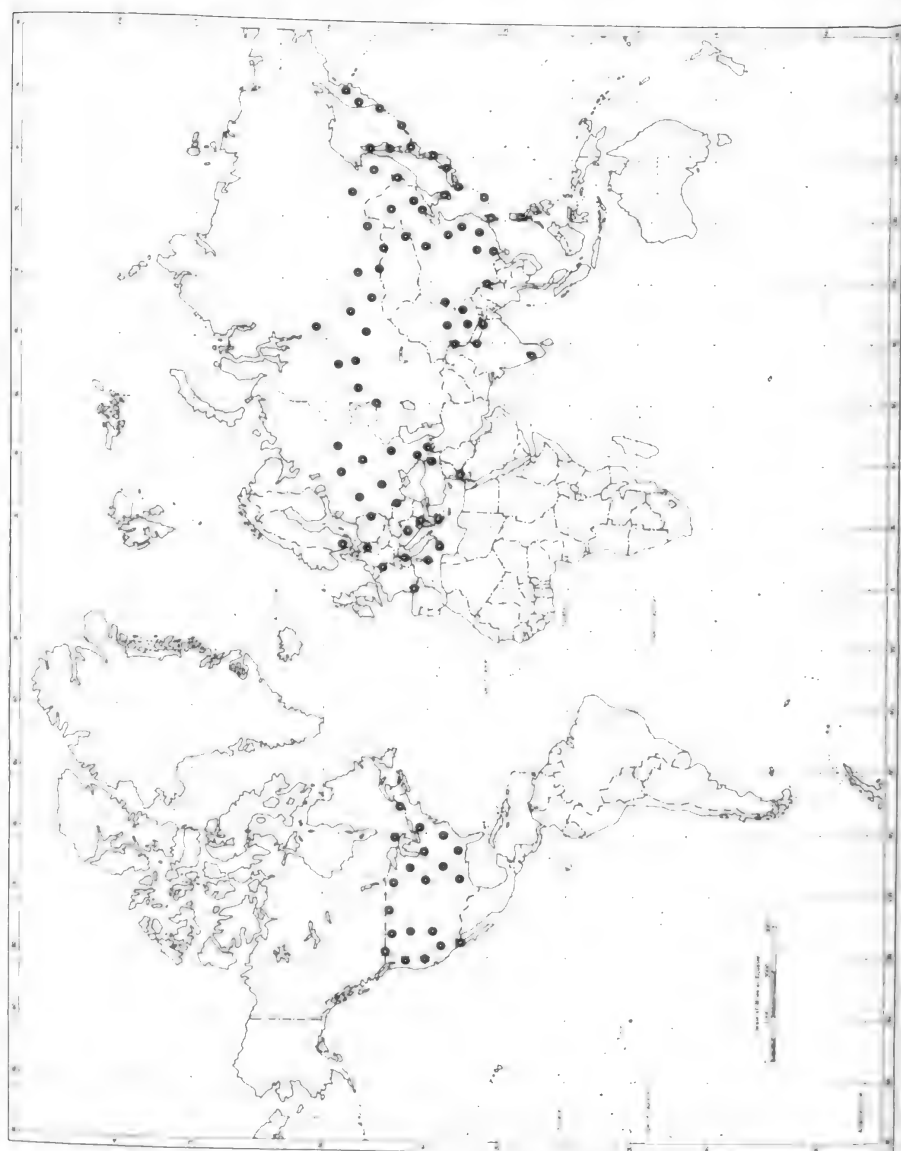


Figure 1. World distribution of the genus *Lillium*.



Figure 2. *Lilium philadelphicum*.



Figure 3. *Lilium martagon*, as seen on the Dalmatian Coast.

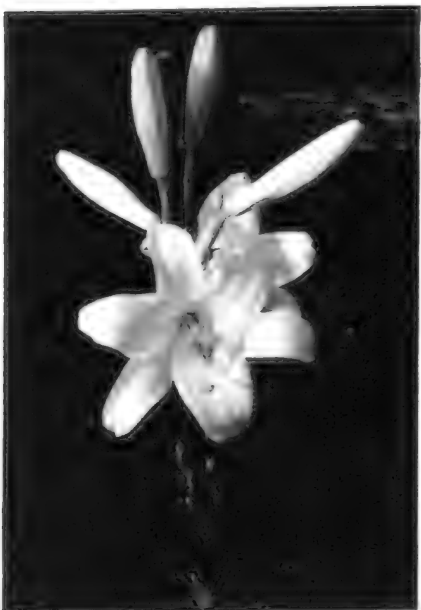


Figure 6. *Lilium candidum*.



Figure 7. *Lilium grayi* illustrating the multiple whorled leaves, characteristic of primitive lily species.

sphere originated in circumpolar lands. The prevailing temperatures between the 10th and 60th North parallels during the Tertiary Period (5-65 million years ago) were antagonistic to most plant life. Fossil evidence documents the existence of numerous temperate genera: **Magnolia**, **Ulmus**, **Acer**, in the Arctic Circle region during the Eocene Period. While similar evidence is lacking for **Lilium**, it is plausible that the genus was distributed in a similar manner during this period. This would account for the wide distribution of **L. philadelphicum** (Figure 2) across North American and **L. martagon** (Figure 3) across Europe and Asia.

As the Tertiary Period progressed, temperatures dropped. Correspondingly, the temperate plants began migrating southward from the Arctic Circle. This migration could have pushed lilies further southward than the current southern-most location of 11° N., where **L. philippinense** and **L. neilgherrense** are isolated in the Philippines and southern India, respectively; they would not have survived the heat of the equatorial region after the Ice Ages unless they were at higher elevations (Baranova, 1966; Woodcock and Stearn, 1950).

Temperature fluctuations during the Quaternary Glacial Period (0-1.8 million years ago), which was the culmination of the cold epoch begun during the Tertiary, greatly affected the continental migration of lilies. It was not as severe in Asia as it was in Europe and North America. A comparison of the global areas under glaciation during the Quaternary Period (Figure 4) with the distribution of the genus (Figure 5) shows that the areas not possessing species closely approximates the areas not under glaciation. Initially North America had three large ice masses occupying the areas of Labrador, the western mountains, and the region to the west of Hudson Bay. These three glacial areas later merged, moved northward and then in the direction of the Atlantic and Pacific oceans. This restricted plant life to the southeastern coast, the coastline of California and Mexico, and the region immediately north of the Gulf of Mexico. In Europe during the height of the glacial period, ice extended from Ireland and England eastward across continental Europe and the USSR almost to 80° W.

The primary method for wide dispersal of lilies is usually by seed. The seeds are not commonly carried by birds, mammals, or wind. Studies by Stoker (1933) postulate that water could have served as the primary agent. The seeds of **L. regale** floated in agitated water for six days before sinking. Seeds immersed in water for 16 days had 30% germination. **L. formosanum** seeds had a greater than 30% germination after a 15 day soak, as well as after floating for three weeks. In this time they could have been carried 750 miles, the distance between Formosa and Nagasaki, in an ocean current moving 1.5 mph.

There were three "waves" of migrations into Europe from Asia: western, northern, and southern (Lighty, 1968). Both the northern and southern waves produced lilies in the Balkans and central Europe. **L. candidum** (Figure 6) arose as a major species in Asia Minor due to the southern wave. **L. martagon** pushed westward across Asia into Europe. It also moved eastward along the Bering Strait, giving rise to the American lilies, all of which have the characteristic multiple leaf whorls.

The whorled leafed lilies (with more than one whorl) are classified as the most primitive. Figure 7 illustrates the whorled leaf growth of the members in this section. Those in North America were cut off from the genus at an early stage of continental drift and evolved independently. The topographical features of western North America account for the large number of coastal species. North American species, which



Figure 4. Glaciated areas (indicated by slash lines) during the Quaternary Ice Age.



Figure 9. *Lilium hansonii*.



Figure 10. *Lilium regale*.



Figure 12. *Lilium caucasicum*.

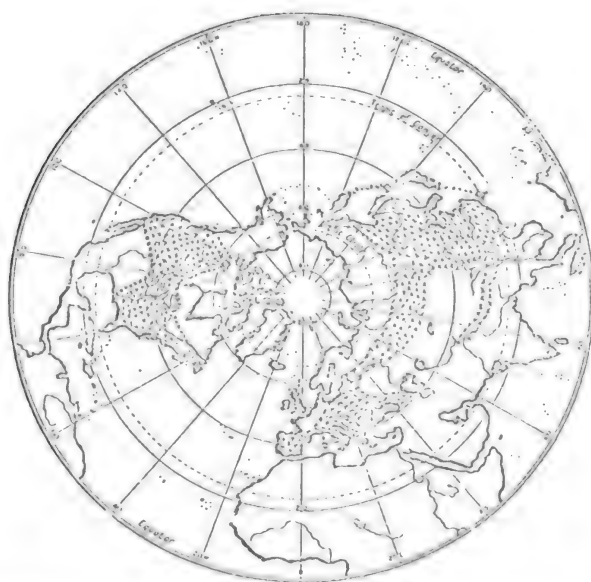


Figure 5. Dissemination of the genus *Lilium* in relation to the areas under glaciation during the Quaternary Ice Age.

are truly stoloniferous and have rhizomatous bulbs, cross readily among themselves—but not as easily with Old World species (Woodcock and Stearn, 1950).

Lighty (1968) postulated that the genera *Lilium*, *Fritillaria*, and *Nomocharis* evolved out of the proto-lilium (Figure 8). Within the genus *Lilium*, *L. hansonii* (Figure 9) seems the most primitive. Stoker (1933) postulates, in looking at ancestral types, that the range of a species is relative to its age. There are species of "equal adaptiveness, equal fertility and . . . environments" that differ in the extent of their distribution. *L. martagon*, an ancestral type, is found across the eastern hemisphere; while *L. regale* (Figure 10), being more recently evolved, is confined to a valley in western China.

SPECIES DISTRIBUTION

EUROPE AND WESTERN ASIA: The European species include *L. albanicum*, *L. aurantiacum*, *L. bosniacum*, *L. bulbiferum*, *L. candidum*, *L. carniolicum*, *L. chalcidonicum*, *L. heldreichii*, *L. jankae*, *L. martagon*, *L. pomponium*, *L. pyrenaicum*, and *L. rhodopaeum* (Popova, 1970; Woodcock and Stearn, 1950). Five of these species are endemic. All species flower in June and July and are martagon types (with the exception of *L. aurantiacum* and *L. bulbiferum*). *L. martagon* has the widest distribution of any species (Figure 11). It is bounded by Portugal on the west (8° W.), extending eastward to 124° E.; the northern boundary is 68° 40' N., continuing southward to the northern part of the Mongolian People's Republic (40° N.). It is a mesophyte, inhabiting forest glades and meadows (Baranova, 1966).

Caucasus and Western Asia species are: *L. armenum*, *L. candidum*, *L. caucasicum* (Figure 12), *L. georgicum*, *L. kesselringianum*, *L. ledebourii*, *L. martagon*, *L. monadelphum*, *L. ponticum*, *L. polyphyllum* and *L. szovitsianum* (Baranova, 1966; Lighty, 1962; Stern, 1938).

EASTERN ASIATICS: The Indian species are *L. nanum*, *L. neilgherrense*, *L. nepalense* (Figure 13), *L. oxypetalum*, *L. polyphyllum*, *L. sherriffiae* and *L. wallichianum* (Stainton, 1970; Thomas, 1957; Woodcock and Stearn, 1950). Lilies and other bulbous members of the Liliaceae are poorly represented in the Himalayas. All of the species are well adapted to growing in higher elevations (3,500-13,500 ft.) and flower during late July to September; an exception is *L. oxypetalum* which blooms in late June (Wyman, 1964).

L. wardii is the only species found in Tibet (Stainton, 1970; Woodcock and Stearn, 1950), growing only in the southeastern region, east of the Himalayas. The lilies in northern Burma and southern Assam include: *L. arboricola*, *L. bakerianum*, *L. euxanthum*, *L. henryi* (Figure 14), *L. mackliniae*, *L. paradoxum*, *L. primulinum*, *L. soulieae*, and *L. tigrinum*. Indo-China and Siam have only *L. poilanei* and *L. primulinum* (Lighty, 1962; Stainton, 1970; Thomas, 1957).

In China, the western region has *L. amoenum*, *L. bakerianum*, *L. brownii* (Figure 15), *L. davidi*, *L. duchartrei*, *L. fargesii*, *L. henryi*, *L. langkongense* (Figure 16), *L. papilliferum*, *L. primulinum* var. *ochraceum*, *L. regale*, *L. sargentiae*, *L. semper-vivoideum*, *L. stewartianum*, and *L. taliense* (Lighty, 1962; Price, 1936; Woodcock and Stearn, 1950); the central part of China includes *L. bakerianum* var. *rubrum*, *L. brownii* var. *viridulum*, *L. callosum*, *L. concolor* (Figure 17), *L. davidi* (Figure 18), *L. fargesii*, *L. henryi*, *L. leucanthum*, *L. primulinum* var. *ochraceum*, *L. speciosum* var.

gloriosoides. Northern China has *L. brownii* var. *viridulum*, *L. davidi*, *L. duchartrei*, *L. leucanthemum*, *L. pumilum* (Price, 1936; Wilson, 1925; Woodcock and Stearn, 1950); northeastern China has *L. brownii* var. *viridulum*, *L. concolor*, *L. medeoloides*, *L. pumilum* (Figure 19), *L. tigrinum*, and *L. tsingtauense*. Southern China has only one species, *L. brownii* var. *australe*. The lilies on Formosa are *L. callosum*, *L. formosanum*, *L. longiflorum* var. *takesima*, and *L. speciosum* var. *gloriosoides* (Price, 1936; Woodcock and Stearn, 1950). *L. formosanum* (Figure 20) is found throughout most of Formosa, inhabiting open country and "herbaceous shelter" regions, growing in valleys and up to 8,500 feet in elevation (Price, 1936). *L. longiflorum* var. *takesima* is located in the Daiton range on Formosa and also grows on the Ryukyu Islands of Japan. The Philippines have only one species, *L. philippinense* (Stern, 1938). Its sole presence here identifies it as the only species able to survive the northern tropics.

The distribution of lily species is best documented for the islands that comprise Japan. Species found in Japan include: *L. alexandrae*, *L. auratum* (Figure 21), *L. callosum*, *L. cordatum*, *L. dauricum*, *L. hansonii*, *L. japonicum*, *L. leitchlinii* (Figure 22), *L. leitchlinii* var. *maximowiczii* (*L. maximowiczii*), *L. longiflorum*, *L. maculatum* var. *monticola*, *L. medeoloides*, *L. nobilissimum*, *L. rubellum* (Figure 23), *L. speciosum*, and *L. tigrinum* (*L. lancifolium*) (Abe, 1980; Baranova, 1966; Lawrence, 1957; Lighty, 1962; Ogilvie, 1957; Ohwi, 1965; Shimizu, 1954, 1954a, 1956, 1959, 1960, 1984?; Woodcock and Stearn, 1950). Few of the lilies inhabiting Japan are endemic. A natural variety of *L. longiflorum* occurs in Formosa. *L. medeoloides* (Figure 24) is also found in the eastern USSR, Kamchatka Island, South Korea, and China (Hulten, 1927). *L. tigrinum*, one of the oldest lilies in cultivation, is also found in a southern maritime province of the USSR. *L. leitchlinii* var. *maximowiczii* ranges from Japan, Korea, and northeastern China to southern maritime USSR. The "primitive." *L. hansonii*, is found in Japan, as well as being distributed on the Asian continent.

The species occurring in Korea and Manchuria are *L. amabile*, *L. callosum*, *L. cernuum*, *L. concolor* var. *pulchellum*, *L. dauricum*, *L. distichum*, *L. hansonii*, *L. leitchlinii* var. *maximowiczii*, *L. medeoloides*, *L. miquelianum*, *L. pumilum*, *L. tigrinum* and *L. tsingtauense* (Figure 25) (Baranova, 1966; Lighty, 1968a, 1970; Woodcock and Stearn, 1950). *L. distichum*, *L. miquelianum* and *L. dauricum*—along with the ancestors of the North American species—have jointed bulb scales (Lighty, 1968). *L. callosum*, *L. cernuum* and *L. distichum* are also found in the USSR and China (Baranova, 1966).

In the far eastern regions of the USSR, we find *L. concolor* var. *pulchellum*, *L. cordifolium*, *L. dauricum*, *L. distichum*, *L. medeoloides* and *L. pumilum*. Siberia has only three species: *L. dauricum*, *L. martagon* var. *pilosiusculum* and *L. tenuifolium* (Baranova, 1966; Hulten, 1927; Vasak, 1976; Woodcock and Stearn, 1950). Both *L. dauricum* and *L. tenuifolium* extend to regions outside the USSR: to the Sea of Japan, and southward into Mongolia and China. *L. tenuifolium* is a xeromorphic species preferring dry southern exposures of stony slopes, scree, or precipices.

NORTH AMERICA: The number of eastern and central species are fewer than their western allies due to less dramatic glacially-induced topographical conditions resulting in fewer ecological niches. The species found here include *L. canadense* (Figure 26), *L. carolinianum*, *L. catesbaei*, *L. grayi*, *L. iridollae*, *L. michauxii*, *L. michiganense* (Figure 27), *L. philadelphicum* and *L. superbum* (Figure 28) (Woodcock and



Figure 14. *Lilium henryi*.

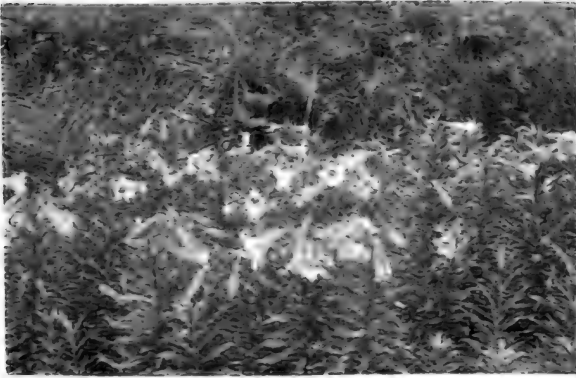


Figure 15. *Lilium brownii*.



Figure 16. *Lilium langkongense*.



Figure 13. *Lilium nepalense*.



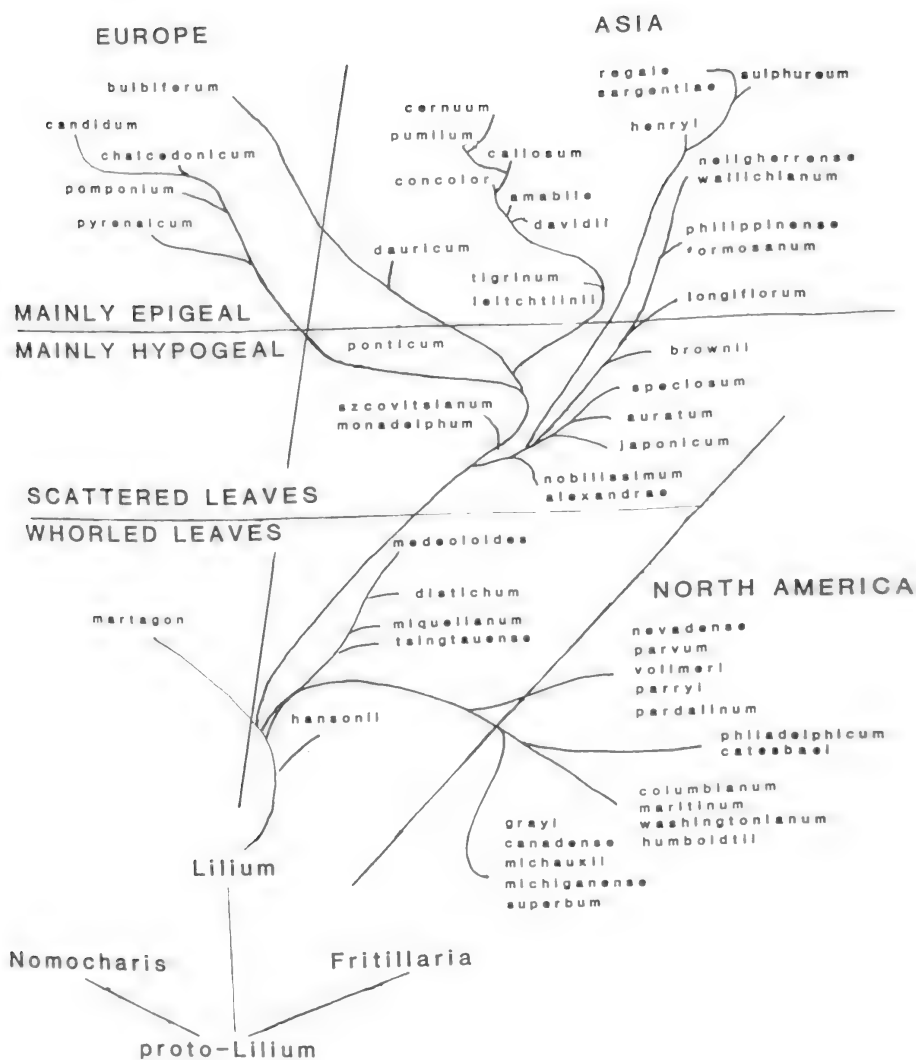
Figure 17. *Lilium concolor*.



Figure 18. *Lilium davidii*.



Figure 19. *Lilium pumilum*.

Figure 8. Proposed evolution of the genus *Lilium*.

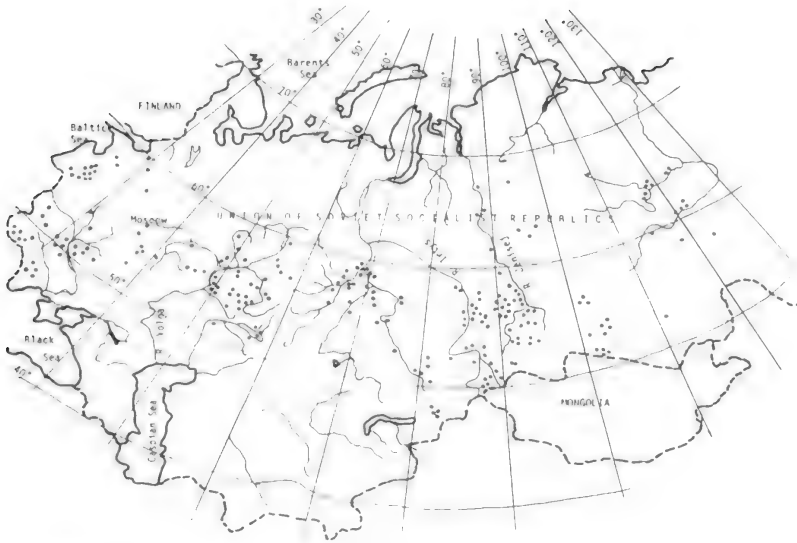


Figure 11. Distribution of *Lilium martagon* in the eastern hemisphere.

Stearn, 1950). Most of these species are well distributed throughout the east coastal regions. The western species are not as cosmopolitan. They include: *L. bolanderi*, *L. columbianum*, *L. humboldtii*, *L. kelloggii*, *L. maritimum*, *L. nevadense*, *L. occidentale*, *L. pardalinum*, *L. parryi*, *L. parviflorum*, *L. parvum*, *L. philadelphicum*, *L. rubescens*, *L. vollmeri*, and *L. washingtonianum* (Figure 29) (Shimizu, 1984?; Stern, 1938; Woodcock and Stearn, 1950).

RELATIONSHIP BETWEEN SPECIES

The most comprehensive work investigating the natural environment of lily species—in an attempt to correlate it with distribution—is that of Stoker (1933). His work is a synopsis of the rainfall, snowcover, relative humidity, and soil temperatures for most species habitats. The information for central Asian and Chinese species was "scanty and in many instances the figures given (were) . . . arrived at by consideration of probabilities." However, the data on North American species are more accurate. Assumptions based on "probabilities" should be regarded as observations needing scientific confirmation.

The importance of altitude in the distribution of lilies is related to the corresponding lower temperatures. The possibility exists that lower temperatures are a selection pressure for species that may be day-neutral and/or requiring a cold treatment for the induction of flowering. Baranova (1966) reported that mountainous species from the USSR do not grow any further north than 48-55° N. Little is known about exotic lilies, such as those from Burma and the Himalayas, as well as which environmental factors induce flower bud initiation in most other species.

Figure 23. *Lilium rubellum*.Figure 20. *Lilium formosanum album*.Figure 25. *Lilium tsingtauense*.Figure 24. *Lilium medeoloides*.



Figure 21. *Lilium auratum*.



Figure 22. *Lilium leitchlinii*.



Figure 28. *Lilium superbum*.



Figure 29. *Lilium washingtonianum*. Native habitat at Big Creek, Fresno County, California.

Seed germination, however, is correlated with latitude (Lighty, 1968). The southern species tend to have immediate epigeal germination, where the cotyledons emerge from the seed and are raised above the soil. The mode of germination has shifted evolutionarily from delayed hypogeal (cotyledons remain in the seed within the soil) to immediate epigeal.

Stoker (1933) stated that lilies did not fall within the rule of long or short days influencing flowering. He classed long day (LD) lilies as ones that flowered June 1–July 15. Examples were *L. dauricum*, *L. brownii*, *L. hansonii*, *L. giganteum*, and *L. superbum*. Short day (SD) lilies flowered before June 1 or after July 15; these included *L. tigrinum*, *L. davidii*, *L. longiflorum*, *L. formosanum*, *L. auratum*, and *L. chalcedonicum*. His classification of LD versus SD responses was not based on experimental evidence. Recent studies have shown that he incorrectly classified at least one species; *L. longiflorum* has been demonstrated to flower without bulb cooling under long day conditions at temperatures below 21°C (Wilkins, 1980).

Kline (1957) and Wyman (1964) have documented the flowering dates for several species grown at one location or in their native habitat. Both fail to mention, however, whether each species was exposed to equivalent of cold treatment. Table I summarizes the blooming dates of several species correlated with latitude. Species flowering early in the season are distributed in regions of higher latitude than those flowering later in the season. There are exceptions, however. *L. michiganense*, *L. philadelphicum* and *L. longiflorum* do not fit this general trend.

Lighty (1968) proposed the most recent theory on the evolution of the genus, based on species relationships (Figure 8). This work included 66 species. He also postulated how the species not included in the study would fit his theory. Unfortunately, he did not analyze the environmental parameters associated with flower bud initiation in any of the species. A major study is needed to determine when floral initials are formed (e.g. before, during, or after environmentally imposed cooling of the bulb and before or after shoot emergence). Lighty's findings demonstrate that lilies found in Japan all have minor morphological differences and show the same basic evolutionary pathway. *L. wallichianum* and *L. neilgherrense*, both having evolved in a similar manner as *L. longiflorum*, are not found in Japan but are located, respectively, in north and south India. The branching of *L. henryi*, *L. sargentiae* and *L. regale* from the evolution of Japanese lilies occurred before *L. speciosum* evolved. These three species are found in China.

Analysis of the speciation process has provided additional information on the evolution of the genus *Lilium*. D.A. Levin (1971) stated the genetic control of reproductive mechanisms, that restrict or curtail the exchange of genes between populations, are necessary for maintaining "genetic integrity and affording evolutionary independence." One such isolating mechanism is the "Wallace effect" (Grant, 1966; Levin, 1971), which can be defined as the development of pre-zygotic barriers preventing female gamete waste, hybridization, and disruptive gene flow. This was important in the rise of Angiosperms to vegetative dominance. A "clean" Wallace effect occurs between two species that are sympatric. One way to generate the Wallace effect is to obtain a unilateral incompatibility response. Incompatibility is a genetically based physiological mechanism that promotes outcrossing (DeNettancourt, 1977). Classically, incompatibility is controlled by one locus (S) with multiple alleles. In species possessing gametophytic self incompatibility (SI) (e.g. the Liliaceae) the SI reaction

occurs in the style and is specifically dependent upon the S allele identity in both style and pollen. Species that are self compatible (SC), when used as females, can be crossed with related SI species, but the reciprocal cross is prevented due to the inhibition of pollen growth down the style (Levin, 1971).

TABLE 1. FLOWERING DATES AND LATITUDINAL CORRELATION AMONG SEVERAL LILIUM SPECIES (41).

Species	Latitude	Flowering Period					
		May	June	July	Aug.	Sept.	Oct.
<i>L. rubellum</i>	40	x	x				
<i>L. martagon album</i>	40/50		x	x			
<i>L. dauricum</i>	50		x	x			
<i>L. concolor</i>	40		x	x			
<i>L. cernuum</i>	40		x	x			
<i>L. japonicum</i>	40		x	x			
<i>L. canadense</i>	45		x	x			
<i>L. brownii</i>	30			x			
<i>L. amabile</i>	36			x			
<i>L. candidum</i>	38			x			
<i>L. tsingtauense</i>	38			x			
<i>L. davidii</i>	28			x			
<i>L. regale</i>	26			x			
<i>L. callosum</i>	46			x	x		
<i>L. sargentiae</i>	26			x	x		
<i>L. formosanum</i> -early	20				x		
<i>L. henryi</i>	20				x	x	
<i>L. longiflorum</i>	30				x	x	
<i>L. formosanum</i> -late	20					x	x

Lewis and Crowe (1958) explained the unilateral incompatibility response in terms of a mutation sequence of the S gene whereby its pollen loses the ability to "negotiate" the styles of SI species. In their theory, the species affected the least from gene exchange would evolve a barrier to gene flow, while those that might suffer the most remain unchanged. Pandey (1969) showed that the selection for S genes could favor the rejection of pollen from an SC sympatric species.

Unilateral incompatibility has been described in several interspecific crosses of *Lilium* (Ascher and Peloquin, 1968). *L. longiflorum* (SI) \times *L. regale* (SC) had 11mm of pollen tube growth, while the reciprocal cross had 80mm growth. The cross of *L. longiflorum* \times *L. formosanum* (SC) and its reciprocal, as well as crosses with other trumpet types, gave a similar response.

The large range of *L. regale* and *L. formosanum* suggest that no Wallace effect was necessary. *L. longiflorum*, on the other hand, has a small range, necessitating the Wallace effect to avoid gamete wastage. *L. longiflorum* (Figure 30) is the most specialized species with regard to habitat, growing only on pumice volcanic soil on the southern Japanese Islands (Figure 31). Its chromosome morphology differs from all other trumpet lilies. The most closely related trumpet is *L. formosanum*, which has a limited, but more extensive range in Japan and Formosa.



Figure 26. *Lillium canadense*. Native habitat at Norwich, Vermont.



Figure 27. *Lillium michiganense*.



Figure 30. *Lillium longiflorum*. Native habitat on Okino, Erabu Shima, Ryukyu Islands.

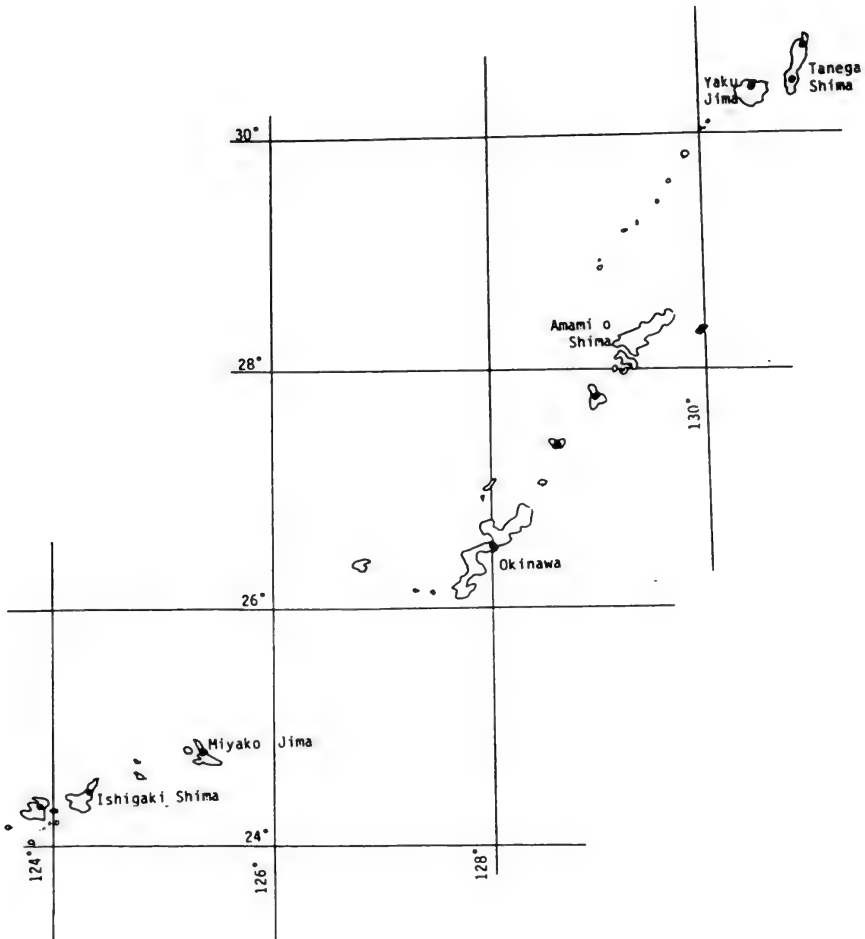


Figure 31. Distribution of *Lilium longiflorum* in the Ryukyu Islands, south of Japan.

The lack of any research on the environmental factors affecting the flowering responses in *Lilium* prevents a more thorough understanding of physiological evolutionary relationships. Such a study would pose an answer as to why *L. longiflorum* has the capacity to respond both to LD and cold treatments for the induction of flowering, as well as having a wider application to understanding the evolution of flowering responses in other genera and families.

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YELLOW STARS: A BRIEF INTRODUCTION TO THE **HYPOXIDACEAE**

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That acute botanist, Robert Brown, proffered the name and family status **Hypoxidaceae** to a group of plants allied to and often included within the **Amaryllidaceae**. He chose the large genus **Hypoxis** as its basis with a few smaller genera allied to it for supporting harmony. Since that time (1814), this group of plants has fluctuated both in constitution and rank. For most of the last century the family was included within the **Amaryllidaceae**, although Baker (1878) published a review of it as **Hypoxidaceae**. Even in a recent account by Cronquist (1981) the family is sunk into a broadly construed **Liliaceae**. Hutchinson (1959) recognized **Hypoxidaceae** as distinct and furnished a concise description and key to genera. The late Airy Shaw in his revision (edition 8) of Willis's "Dictionary" (1966) accepted **Hypoxidaceae** but included within it (as we now think, wrongly) two genera (**Wachendorfia** and **Xiphidium**) usually regarded as members of the related but distinct family **Haemodoraceae**. Geerinck's (1969) revision of the family accepts six genera: **Curculigo**, **Hypoxis**, **Pauridia**, **Campynema**, **Campynemanthe**, and **Rhodohypoxis**. Hutchinson accepted virtually the same genera as Geerinck but includes **Rhodohypoxis** within the genus **Hypoxis**. Earlier classifications recognized a number of other genera (listed below as synonyms). The latest statement may be that of Dahlgren, Clifford and Yeo (1985) who separate **Campynema** and **Campynemanthe** as the family **Campynemaceae** Dumort. (1829), and accept as true **Hypoxidaceae** the genera **Hypoxis**, **Spiloxene**, **Rhodohypoxis**, **Curculigo**; also two others, **Empodium** and **Pauridia**, which are doubtful. The following tabular exhibit give the components of **Hypoxidaceae** (and **Campynemaceae**).

COMPARISON OF THE TREATMENT OF GENERA

HYPOXIDACEAE AND CAMPYNEMACEAEComponent Genera
(after Dahlgren, Clifford, and Yeo, 1985)**HYPOXIDACEAE**

Genera:	1. Hypoxis	90	Estimated number of species
	2. Spiloxene	30	
	3. Rhodohypoxis	4	
	4. Pauridia	2	
	5. Curculigo	10	
	6. Empodium	10	

CAMPYNEMACEAE

Genera:	1. Campynema	2
	2. Campynemanthe	1

HYPOXIDACEAE

Component Genera
(after Hutchinson, 1959)

Genera:	1. <i>Campynema</i>	—	Estimated number of species
	2. <i>Campynemanthe</i>	—	
	3. <i>Hypoxis</i>	—	
	4. <i>Pauridia</i>	—	
	5. <i>Curculigo</i>	—	

HYPOXIDACEAE

(after Geerinck, 1969)

Genera:	1. <i>Campynema</i>	2	Estimated number of species
	2. <i>Campynemanthe</i>	1	
	3. <i>Curculigo</i>	35	
	4. <i>Hypoxis</i>	144	
	5. <i>Pauridia</i>	1 or 2	
	6. <i>Rhodohypoxis</i>	3	

The above table shows that not only are the numbers of genera in the family uncertain, but the numbers of acceptable species are in doubt. The figures given for the latter by Geerinck are probably accepted at face value from the literature; the more conservative estimates of Dahlgren *et al.* are either based on newer information or on a much more aggregative species concept. The inclusion of *Campynema* and *Campynemanthe* (both are closely related) in the miniscule family *Campynemaceae* does not end the taxonomic problem—two genera, *Pauridia* and *Empodium*, are still somewhat discordant within *Hypoxidaceae*, as is noted below.

ENUMERATION OF THE GENERA OF *HYPOXIDACEAE* AND *CAMPYNEMACEAE*, WITH
SYNONYMS, TYPE-SPECIES, AND DISTRIBUTIONS
(Largely after Geerinck, 1969)

1. *Campynema* Labill. (1805).—Syn. *Campylonema* Labill. ex Schult. & Schult. f. (in Linn. Syst. Veg. ed. 7, 1830).
Type-species: *C. lineare* Labill.
Distribution: Tasmania (*C. lineare*) and New Caledonia (*C. neocaledonicum*).

Placed in *Hypoxidaceae* by Geerinck; in *Campynemaceae* by Dumortier (1829) and Dahlgren, Clifford and Yeo (1985).

2. *Campynemanthe* Baill. (1893).
Type-species: *C. viridiflora* Baill.
Distribution: New Caledonia.

Placed in *Hypoxidaceae* by Geerinck; in *Campynemaceae* by Dahlgren, Clifford and Yeo (1985).

3. **Curculigo** Gaertn. (1788).—Syn. *Fabricia* Thunb. (in part); *Molineria* Colla; *Forbesia* Eckl.; *Aurota* Raf.; *Empodium* Salisb.

Type-species: **C. orchoides** Gaertn.

Distribution: Africa, Madagascar, Seychelles, India to South China and South Japan, Micronesia, Melanesia, Malaysia throughout, Australia (Qd.), South America north to Antilles.

Widely differing numbers of species attributed to the genus because of disagreement on synonymy; Geerinck gives 35 species but includes **Empodium** Salisb., a genus accepted as distinct by Dahlgren *et al.*, which contains about 10 species.

4. **Hypoxis** L. (1759).—Syn. *Fabricia* Thunb. (in part); *Niobea* Willd. ex Schult. & Schult. f. in Linn. Syst. Veg. (1830); *Niobaea* Willd. ex Spach (1846), orthogr. mut.; *Franquevillea* Miq. in Zoll. (non *Franquevillea* Salisb.); *Ianthé* Salisb. (and *Janthe* Salisb., orthogr. mut.: *Spiloxene* Salisb.).

Type-species: **H. hirsuta** (L.)Cov. (syn. *H. erecta* L.,).

Distribution: Sect. **Hypoxis** (118 species according to Geerinck) with 98 in Africa, 1 in Asia, 2 in Australia, and 17 in South and North America: Sect. **Ianthé** (Salisb.)Benth. with 26 species of which 23 are in South Africa and 3 in Australia, Tasmania, and New Zealand.

Spiloxene Salisb. is accepted as a distinct genus by Dahlgren *et al.*

5. **Pauridia** Harv. (1838).—Syn. *Fabricia* Thunb. (in part). *Paurida* (orthogr. mut. in Hutchinson).

Type-species: **P. minuta** (L.f.)Dur. & Schinz (syn. *Fabricia minuta* Thunb.). Syn. *Ixia minuta* L.f.; *Pauridia hypoxidioides* Harv.

Distribution: One, possibly two species in the Cape region, South Africa.

Somewhat anomalous in the family because of its nuclear endosperm and 3 stamens per flower.

6. **Rhodohypoxis** Nel. (1914).

Type-species: **R. baurii** (Bak.)Nel.

Distribution: South Africa, 3 species.

KEY TO GENERA (After Geerinck, 1969)

Tepals quite free; stamens inserted at their base

Seeds subglobose with a black coat

Stamens 6

Ovary prolonged in a long, sometimes short, rarely almost absent tubular projection; fruits fleshy, not dehiscent, berry-like **Curculigo**

Ovary not prolonged as a tubule; fruit loculicidally capsular **Pauridia**

Stamens 3 **Hypoxis**

- Seeds angular with reddish-brown coat
 Tepals each with a large fleshy gland on the inner face; style 1; ovules 2 per cell **Campynemanthe**
 Tepals lacking such interior glands; style trifid; ovules many per cell ... **Campynema**
 Tepals united shortly at base; stamens inserted on that tube at different levels ... **Rhodohypoxis**

BRIEF DESCRIPTION OF HYPOXIDACEAE (INCLUDING CAMPYNEMACEAE)

Herbs with radical strongly nerved or pleated entire leaves arising from corms or rhizomes, usually compact and tufted. Indument when present often tomentose or arachnoid, hairs white to buff or blackish. Inflorescences stalked, the flowers in compact bracteate heads or racemose, sometimes single. Flower with six equal tepals radially spreading, subpersistent, free or shortly united at base. Stamens 6 or 3, anthers opening by either in- or extrorse slits. Gynoecium 3-celled; style compound of 3 (entire or only tips segregated), ovary inferior. Ovules biseriate, on axile placentation, numerous or sometimes few. Fruit capsular or berry-like. Endosperm copious. Seed coat with a thick phytomelanin layer; seed lacking starch.

Special characters: stomata paracytic; nectaries none; tapetum periplasmodial; alkaloids and steroidal saponins absent; chelidonic acid present in some species.

GEOGRAPHIC DISTRIBUTION

Campynemaceae has a compact distribution: one genus endemic to New Caledonia, the other genus with a single species in New Caledonia and a second in Tasmania. The biogeographic link between Australia and New Caledonia has been well established.

The genus with the largest number of species, **Hypoxis** (including **Spiloxene**) is also the most widely distributed. Although more heavily represented in the southern hemisphere, it extends north into Canada and is known in Africa, East Asia, Indomalaysia, and Australia. **Curculigo**, with the inclusion of **Empodium**, is pantropical with again a prevalence in the southern hemisphere and equatorial regions, but reaches southern Japan and, in the Americas, the Caribbean. **Pauridia** and **Rhodohypoxis** are South African.

GENERAL REMARKS

The general information available about Hypoxidaceae is not abundant. Various floristic works should be consulted to obtain a spectrum of data; reliability varies according to the age of the source of information. What follows here is a rather random compendium of such data and by no means should be taken to be either complete or even-handed. Indeed, the point of this contribution is to elicit notes from those with specific, recent information; including of course, experience with cultivation.

From an economic point of view the **Hypoxidaceae** appear to have minor significance. The rhizomes are said to be eaten, either raw or roasted, by Australian aborigines (Roth, 1901), with specific reference to **Curculigo ensifolia**. The fruits of **Curculigo** may also be edible. At least one species of **Curculigo** produces fruits which contain a chemical substance that we would regard as a "sugar substitute"; it imparts a long

lasting, sweet taste both to the fruit and to any other foods subsequently eaten. Ridley (1907) describes the result as "an unpleasantly sweet taste"; though this may depend (as it does with saccharine) on the quantity eaten. The natural occurrence of such a compound might suggest that *Curculigo* fruits could have some commercial prospects, but this seems not to be so. This phenomenon is most noticed in *C. latifolia* (known in Malay as "lumbah"), which is frequent in Malaysia.

Curculigo orchioides, usually a species occurring in dry grasslands, has been used medicinally in India (sometimes called "black musli"), where it is regarded as a tonic and may be employed in cases of asthma, jaundice, piles, diarrhoea, colic, and even gonorrhoea. Somewhat similar usage is known in the Philippines. The root alone may be prepared for use, or mixed with carminative preparations. A South American species (*C. scorzonnerifolia*) is said to have abortifacient properties.

Several species of *Curculigo* have leaves used as a source of fiber—including false hair (in Luzon). Borneo Dyaks use the fiber to work up fishing nets.

Hypoxis aurea (and perhaps other species) also appears to have medical applications. The roots of this species form an element in the traditional Chinese pharmacopeia, and are valued as a tonic.

In horticulture, there has been little interest in this group of plants except as curiosities. Some unkind remarks have been made: Roxburgh, in his "Flora Indica," states (of *Curculigo orchioides*) "it is a plant of no great beauty; nor are its flowers fragrant; variety alone must recommend it to a place in the flower garden." Common names such as "Golden-eyed Grass" (for several species) suggest that some may appreciate its modest virtues. About *Curculigo recurvata*, Ridley (1907) writes: "A very beautiful variety of this with the upper side of the leaves silvery and the back purple has been found by Mr. Curtis at Ipoh in Perak." Such forms may have implications for horticultural development, but are liable to be ignored or rejected in their own countries (where the "imported" has more status). One difficulty with *Curculigo* is that the heads of the inflorescences are often water-filled; as the flowers decay and deliquesce, there is a rather unsightly "muck" that accumulates within the bracts. The individual flowers do not remain vivid for long, and only a few are open at any given time. Despite such problems, there are some hypoxids in gardens. Bailey's "Manual of Cultivated Plants" lists *Hypoxis hirsuta*, *Curculigo capitulata*. He states that *C. latifolia* has leaves "curving, graceful and decorative."

Neal (in "Gardens of Hawaii") calls *Curculigo* (*Molineria*) *recurvata* "a common garden plant in Hawaii grown chiefly for its foliage..."

ILLUSTRATIONS

Technical illustrations to show the family characters may be found in various textbooks. More attractive illustrations are uncommon; pleasing drawings in black-and-white are in works such as Moreley and Toelken, Hutchinson's "Families of Flowering Plants," and other floras or standard references. A photograph of *Curculigo latifolia* is included here (Figure 1), from a plant growing in the Genting Highlands, Pahang, Malaysia (preserved in the herbarium as no. 6637).

The South African and perhaps the Australian species are more desirable for horticulture. Pole Evans (1925), Thompson (1969, 1978), and Verdoorn (1947, 1949)

have illustrated and described some of the most attractive of the **Hypoxidaceae**. Those such as the **Spiloxenes**, with the large floral, central "spot" are of particular interest; they may have white flowers with a bluish center, or orange flowers with a blue-black center. The species of **Hypoxis** and the "Empodiums" often have yellow flowers. These species tend to have corms which remain dormant in dry summer months. Flowering may be slow, sometimes first at age 3 or 4. Old, persistent discoid corms at the base of the current corm give an approximate idea of the plant's age.

The illustrations by Wight (1853) give a good idea of the form and structure of the flower and fruit of **Curculigo** and **Hypoxis**.

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Figure 1. *Curculigo latifolia*: from the Genting Highlands (Pahang) in Malaysia (Stone 6637). Note basal inflorescences, with compact heads of flowers, pale whitish bracts, and several open, yellow flowers. The flowers are about $\frac{1}{2}$ inch in diameter; the leaves broad, pleated, and 2 ft. long or more. This is a species of the mid-montane forest and favors gullies, forest margins, and like localities with partial shade and ample moisture, and soils derived from granite.

NOTES ON THE CULTIVATION OF SOUTH AMERICAN BULBOUS PLANTS

JOSE A. CASTILLO

JUJUY 1037

(1804) EZEIZA

BUENOS AIRES, ARGENTINA

THE IPHEIONS (*Ipheion*: Alliaceae)

Ipheion uniflorum (Lindl.) Rafin. is one of the best known and most widely grown of all South American bulbous plants. Few, however, know of the diversity found within the genus and its allies. This group of plants is particularly difficult taxonomically and its members have in the past been placed in the genera *Milla*, *Triteleia*, *Brodiaea*, *Beauverdia*, among others. There still exist differing opinions on their identity among botanists, some including them in *Ipheion* and others in *Nothoscordum* and *Tristagma*. It is not my intention to fuel this taxonomical controversy (although it seems the inclusion of the yellow flowered species in *Nothoscordum* is well founded), but to attract the attention of skilled growers to these endangered species—one probably extinct. Also, it would be useful to provide hints on their habitats, life cycle, cultivation, etc.

IPHEIONS IN THE WILD

All of the species mentioned here are winter growers with a summer dormancy. They inhabit hilly country (soil pockets among rocks) and open grasslands in regions with mild temperate climates. Except for certain populations of *I. hirtellum* (Kunth.) Traub and *I. sellowianum* (Kunth.) Traub, they do not occur in subtropical climates. Natural soils are neutral to slightly alkaline. Acid red clay is the soil in which the populations of the two species mentioned above are found. Average annual rainfall is 800mm-1000mm distributed throughout the year. It is important to note that they receive summer rainfall while they are dormant; this suggests the proper way to handle them in cultivation, and perhaps why *I. uniflorum* does so well in England. Some (*I. sellowianum* is a good example) retain living roots the year round. Cultivation includes giving the plants a summer dormancy in deep shade in hot summer climates like California and the Gulf States; there they should receive light waterings every ten days or so to prevent dessication.

CULTIVATION

Ipheions make first class pot plants and undoubtedly they are easier in containers than in the garden where their small size would look lost among larger plants. A 16cm (ca. 7") clay pot is most suitable for some 5-6 bulbs, giving them room to spread their root systems and offset freely. As soon as the weather cools in late March (Sept.-Oct. in the Northern Hemisphere) the pots should be taken to a sunny place (exposure in the wild is always in full sun) and normal watering resumed. By April, natural rainfall

is sufficient; they seldom need artificial waterings. Different species flower at different times during fall, winter and spring; by growing several, an interesting and long season of flowering is obtained. As soon as the flowers fade the swollen ovaries lean downward until the capsules bury themselves in the ground. Since the bulbs offset freely if not exposed to the air for long periods, it is seldom convenient to let them set seed. It is safer to remove any faded flower and rely on offsetting for reproduction. Repotting is best done as soon as the foliage withers completely; any offset is potted separately. They resent being exposed to dessication. If sent by mail, it is advisable to use plastic bags with dry peat to prevent shrivelling. The dormant bulbs should on no account be left in a hot exposure in full sun, especially if they might be heavily watered, as they easily rot. A suitable mix is any commercial potting loam, coarse grit and charcoal. Low nitrogen fertilizers are used during the season of growth. Bonemeal is quite adequate and they thrive on it. Potassium sulphate is particularly useful in small doses. Here in Ezeiza and in most of their native habitats slight frosts ($-1^{\circ}\text{C}/-2^{\circ}\text{C}$) are experienced during winter without noticeable harm. Some winters we have as many as 90 days of slight frosts at night. Hardiness of *Ipheion uniflorum* is well known. The only species that seems to resent frosts is the one known in England as *Ipheion uniflorum* 'Rolf Fiedler.' To give a better idea of conditions in this region, a table is included.

TABLE 1. AVERAGE TEMPERATURE RANGE AND NUMBER OF DAYS WITH RAIN IN EZEIZA

Month	Temperature Range	Days with Rain
Jan.	Max. Av. Temp. above 26°C .; Temp. at dawn and dusk, $20-26^{\circ}\text{C}$.	10
Feb.	Max. Av. Temp. above 26°C .; Temp. at dawn and dusk, $20-26^{\circ}\text{C}$.	7
Mar.	Daily Temp. between $20-26^{\circ}\text{C}$.; Night temp. below 20°C .	9
Apr.	Max. Mean Temp. below $20-22^{\circ}\text{C}$.; Cool nights	8
May	Max. Mean Temp. below 20°C .; Cool nights	8
June	Max. Mean Temp. below 15°C .; Slight frosts at night	9
July	Max. Mean Temp. below 15°C .; Slight frosts at night	8
Aug.	Max. Mean Temp. below 15°C .; Slight frosts at night	8
Sept.	Max. Mean Temp. below 20°C .; Danger of frost at night	7
Oct.	Daily Temp. between $20-26^{\circ}\text{C}$.; Temp. at dawn and dusk below 20°C .	11
Nov.	Daily Temp. between $20-26^{\circ}\text{C}$.; Temp. at dawn and dusk below 20°C .	9
Dec.	Max. Av. Temp. above 26°C .; Temp. at dawn and dusk between $20-26^{\circ}\text{C}$.	8

Foliage in all species appears above ground in April and starts to wither in November.

IPHEION UNIFLORUM (LINDLEY) RAFINESQUE

This is the best known of all the species. It grows and readily increases by offsets. Foliage is glaucous. Flowers appear in Spring (October here). There is much variabil-



Figure 1 *Ipheion uniflorum album*, photo by Anibal Luchetti

Figure 2 *Ipheion uniflorum* 'Wisley Blue,' photo by Lady Christine Skelmersdale





Figure 3. *Ipheion uniflorum violaceum* photo by Anibal Luchetti

Figure 4. *Ipheion uniflorum* form collected by John Christie at Punta del Este, Uruguay, photo by Anibal Luchetti



ity within this species: some wild forms have tiny flowers less than 2cm in diameter; whereas, *Ipheion uniflorum* var. *album* has forms with flowers 6cm in diameter (Figure 1). Leaf size is variable—the largest forms being the only ones found in cultivation. The best known are 'Wisley Blue' (Figure 2) and 'Froyle Mill' (Figure 5); the first a pale violet and the second an unusual deep purplish-mauve-magenta. Here the cultivated forms are *I. uniflorum* var. *album*, with very large white flowers, and *I. uniflorum* var. *violaceum* (Figure 3), with large pale violet flowers. Also of interest are two clones of a deep violet, and one collected by Dr. John Christie in Punta del Este, Uruguay (Figure 4). This latter has flowers of a most exquisite shape and the tepals are outwardly striped reddish purple.

IPHEION SESSILE (PHILIPPI) TRAUB

This species (Figure 6) occurs in Uruguay and is easy to grow, increasing fairly well by offsets. The flowers are white and appear in June (early Winter).

IPHEION VITTATUM (GRISEBACH) TRAUB

An easily cultivated species of Argentina and Uruguay. Flowers are white and appear in June.

IPHEION HIRTELLUM (KUNTH) TRAUB

This is the earliest flowering species (April). Flowers are yellow (Figure 7). Some populations inhabit subtropical regions.

IPHEION SELLOWIANUM (KUNTH) TRAUB

This species has yellow flowers blossoming in August. Some clones make offsets difficult to separate from the mother bulb without damage. It also occurs in subtropical regions, and it would be advisable to know the collecting data if material eventually becomes available.

IPHEION DIALYSTEMON GUAGLIANONE

The yellow flowers appear in August (Figure 9). Almost extinct, this beautiful species offsets easily.

IPHEION TWEEDIANUM (BAKER) TRAUB

This is the rarest of all species in the group; all efforts to collect it in a living state have failed. It may well be extinct. With the present amount of information on cultivation of rare bulbs, it is unfortunate that no collections of living material were made in the past.

IPHEION UNIFLORUM 'ROLF FIEDLER' HALLIWELL

This is one of the most striking species (Figure 10); distributed years ago by the late Dr. Gomez Rupell, it was named after the great South American alpine expert, Dr. Rolf Fiedler. There was much guessing about the wild origin of this plant until it was found in Punta del Este and Piriapolis, Uruguay, by Dorotea Schultz, G. Pratt and Gustavo D'Antiochia in recent years. It was described as a form of *I. uniflorum*, but they are obviously different taxa when compared side by side. The color of its flower is a most beautiful, deep sky blue. The plant is less slender than the forms of *I. uniflorum*. Also, the color and shape of the leaves are different. Offsets develop at the end of underground runners some distance from the mother plant. These runners eventually dry out leaving only the bulblets that grew at their tips. Flower shape is also different—tepals are rounded instead of oblong. This writer has no doubts 'Rolf Fiedler' will eventually be given specific status. Cultivation is similar to the others, but to obtain a deeper blue the plants should be given gentle warmth while in bud and anthesis. This plant seems to resent the occasional "hard" frosts (down to -6°C) experienced here. Its coastal native habitat in Uruguay is warmer than the Buenos Aires region.

The nomenclature used is mainly that of Guaglianone in *Sinopsis de las especies de Ipheion Raf. y Nothoscordum Kunth (Liliaceae) de Entre Rios y regiones vecinas*. All the species mentioned above (except *Ipheion uniflorum*) are endangered; every effort should be made to preserve them in cultivation and thus prevent their eventual extinction. Populations in some cases are reduced to a few dozen individuals.

GETHYUM ATROPURPUREUM R. A. PHILIPPI (ALLIACEAE)

This is one of the fabulous *Gilliesiae*, a tribe of the *Alliaceae* from Chile, Argentina, and Peru; very rare and on the verge of extinction. They are not beautiful in a conventional sense, but floral morphology is so unusual as to make them fascinating additions to any bulb collection. *Gethyum atropurpureum* is a winter grower and flowers in early spring (Figure 11). Cultivation is easy in clay pots with gritty soil and full sun. It demands protection from hard frosts. Reproduction is by offsets and seeds. During its summer dormancy, it should on no account receive any water—it will rapidly rot. There is an interesting article on this group in *Herbertia* 6:136 (1939), although the measures for some of the species may be inaccurate. My plants regularly flower and are far smaller than those described in the article.

AMARYLLIDS**HIPPEASTRUM ANGUSTIFOLIUM PAX (AMARYLLIDACEAE)**

This is the fascinating species distributed years ago by the late Dr. Gomez Rupell (Figure 12). Most of those plants subsequently died of virus diseases and probably none of them survive in cultivation. This plant inhabits marshes with running water and full sun in the Argentinian provinces of Corrientes and Misiones and the Brazilian

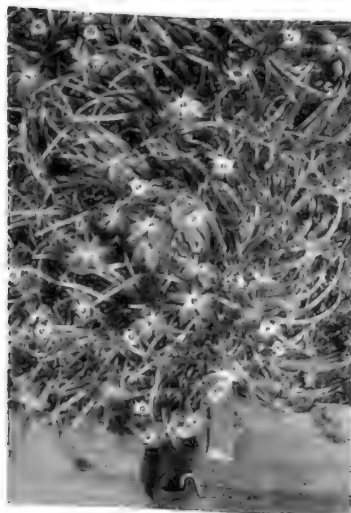


Figure 5. *Ipheion uniflorum* 'Froyle Mill,' photo by Lady Christine Skelmersdale.



Figure 7. *Ipheion hirtellum*, photo by Jorge Veit.



Figure 6. *Ipheion sessile*, photo by Jorge Veit.



Figure 8. *Ipheion selowianum*, photo by Gustavo D'Antiochia.



Figure 11. *Gethyum atropurpureum*, photo by Anibal Luchetti.



Figure 9. *Ipheion dialystemon*, photo by Anibal Luchetti.



Figure 10. *Ipheion uniflorum* 'Rolf Freden', photo by Jorge Vent

state of Rio Grande do Sul. Climate in the wild is subtropical and the secret of its proper cultivation is warmth. This plant demands high temperatures.

TABLE 2. TEMPERATURE RANGES DURING SEASONAL GROWTH FOR *HIPPEASTRUM ANGUSTIFOLIUM*

Month	Temperature Range in the Wild
Oct.	(Starts growing and flowers) Max. Mean Temp. above 26° C
Nov.	Max. Mean Temp. above 26° C
Dec.	Max. Mean Temp. between 32-36° C
Jan.	Max. Mean Temp. between 32-36° C
Feb.	Max. Mean Temp. between 32-36° C
Mar.	Max. Mean Temp. between 32-36° C
Apr.	Max. Mean Temp. between 32-36° C
May	Max. Mean Temp. above 26° C

In June the plants enter several months of dormancy caused by increasingly lower temperatures; foliage is retained in the wild. In cultivation the leaves die away without apparent damage to the plant. It can be grown in large plastic containers (at least 30cm in diameter) without holes and during its winter dormancy these must be taken to a greenhouse where the minimum temperature would not drop under 10° C. Watering should not be withheld even in winter; during the rest of the year (when the plant is in full growth) daily waterings to replenish the level in the container will imitate the running water of their native marshes. This species has very large bulbs with huge root systems and frequently (something to be found in all the Amaryllidaceae) the plants will not flower until roots reach their original size. Therefore, care should be exercised to prevent damaging the tips of the roots. Reproduction is both by offsets which are produced quite rapidly and by seeds. In the wild, these daughter bulbs appear at the end of underground runners at a good distance from the mother bulb. Exposure to full sunlight and so abundant a water supply may seem strange to those growing the shade loving subtropical species of *Hippeastrum*, but this is a most amazing adaptation of this species to colonize an open habitat. The only other species of *Hippeastrum* in the area, *H. petiolatum* Pax (widely distributed in the past by the late Dr. Gomez Rupell as *Amaryllis argilagae* Traub), inhabits gallery forests in deep shade—but with far less water available (only from rains). Living in running water is what lets *Hippeastrum angustifolium* survive the fierce sun of its subtropical habitat. As experience has shown, all species of *Hippeastrum* are susceptible to virus disease; it is extremely important to control the aphids that act as carriers.

HIPPEASTRUM TUCUMANUM HOLMBERG [H. ARGENTINUM (PAX)HUNZ.]

A summer grower, this species is "easy" and flowers reliably every year if given very dry conditions during winter dormancy. It inhabits mountain slopes beneath shrubbery and semi-shaded forests. It is found in subtropical regions and also at colder elevations. It offsets freely, and can be reproduced from seed, although it may take many years to reach flowering size. Mix should be very gritty and a program of regular fertilizing is beneficial during its growth season. Temperatures in the wild are

high, but during dormancy the critical factor is not heat but drought. Flowers are deliciously scented (Figure 13).

IRIDS

CYPELLA OSTENIANA BEAUVERD (IRIDACEAE)

This is a very rare species inhabiting a few hills in the Departamento de Lavalleja, Uruguay (Figure 14). Population is presently reduced to a handful of individuals. A winter grower with summer dormancy, it inhabits places with gritty soil among shrubbery. Exposure is in full sun; the soil is apt to get very hot during its summer dormancy. It flowers later in the Spring than most other Cypellas, late November and December. It is very easy to grow, some 5-6 bulbs to a 16cm pot with gritty soil in full sun. It can take light frosts without harm and reproduces itself easily by seed. It is unfortunate that this pretty little plant is not more widely grown as a means to preserve numbers in cultivation. Heavy grazing and intentional fires are decimating the already small wild population. This species also receives summer rains while dormant.

CYPELLA HERBERTI (LINDLEY)HERBERT

Cypella herberti is a widespread irid species in South America and its habitat ranges from the acid red soils of subtropical Argentina, Paraguay and Brazil to the hilly, cool winter country of southeastern Argentina (Figure 15). *C. herberti* ssp. *brevicristata* (sometimes treated as a separate species) occurs in Artigas and Bella Union, Uruguay, and in Monte Caseros and Cuatro Bocas, Argentina; its habitat is subtropical with exposure in full sun among grass and acid, red clay soils (Figure 16). These soils are nitrogen poor. Cultivation for both forms in raised beds and full sun (with only slight frosts) is particularly successful; sometimes the plants increase by offsets. *C. herberti* ssp. *brevicristata* can be grown in styrofoam pots in gritty soil. The growing season is during winter with a summer dormancy, although *C. herberti* is successfully grown in England and other cold climate countries by reversing this procedure. Both forms receive summer rains in the wild and plants in cultivation demand occasional waterings when dormant.

HERBERTIA LAHUE (MOLINA) GOLDB. SSP. AMOENA (GRISEBACH) GOLDBLATT (SYNONYM: *TRIFURCIA LAHUE*) (IRIDACEAE)

This is one of those species with an unfortunate nomenclatural history, having been placed in several genera (Figure 17). They are known in England as *Herbertias*, and here in South America as *Alophias*. This plant is widely distributed in England under the erroneous name of *Herbertia pulchella*. It is a winter grower flowering in spring. Dormancy is in summer under hot conditions. Like *Cypella herberti*, it is found in acid, red clay in subtropical regions; also in slightly alkaline soils in cooler areas. It is easily grown in clay pots with loam or in styrofoam pots with a gritty mix. During dormancy, the pots should be taken to a place in semi-shade where they can receive occasional waterings to prevent shrivelling. Reproduction is by seeds.



Figure 14. *Cypella ostieniana*, photo by Gustavo D'Antiochia.



Figure 12. *Hippeastrum angustifolium*, photo by Jorge Veit.



Figure 15. *Cypella herbertii*, photo by Jorge Veit.



Figure 13. *Hippeastrum tucumanum*, photo by Gustavo D'Antiochia.

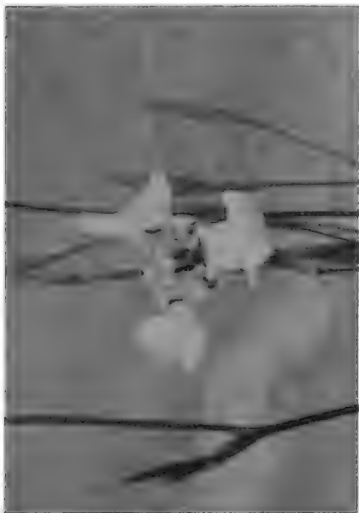


Figure 16. *Cypella herberti* ssp. *brevistata*, photo by Gustavo D'Antiochia.



Figure 18. *Herbertia pulchella*, photo by Gustavo D'Antiochia.



Figure 17. *Herbertia lahue* ssp. *amoena*, photo by Gustavo D'Antiochia.



Figure 19. *Anemone decapetala*, photo by Gustavo D'Antiochia.

HERBERTIA PULCHELLA SWEET (SYNONYM: *TRIFURCIA PULCHELLA*)

This is the true **Herbertia pulchella**, a wonderful species of Uruguay (where it is practically extinct) and southern Brazil (Figure 18). It is a winter grower with summer dormancy. It flowers in Spring (October here) and cultivation is easy in clay pots with gritty soil and full sun. Reproduction is by seeds which germinate easily during the normal season of growth. It appreciates protection from frosts. There is summer rain during its dormancy; therefore, the plants should get light regular waterings then to prevent dessication.

A BULBOUS DICOT**ANEMONE DECAPETALA GMELIN (RANUNCULACEAE)**

This is an interesting species of Argentina and Uruguay—surprisingly it is also found in Texas (Figure 19). It is interesting to note that there are three species of bulbous plants that occur in both regions. This species inhabits hilly country and sometimes open grassland. Cultivation in gritty soil is easy and it can be reproduced by seed. A winter grower, it receives rains during its summer dormancy. Flowering is in spring. It is not bothered by our slight frosts. Exposure should be in full sun.

SUMMARY

I would like to express my appreciation to all the wonderful people that work tirelessly (and often hopelessly) to preserve our marvelous natural heritage.

MAJOR COLOR BREAKTHROUGH IN HYBRID CRINUM

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In 1981 I had a discussion with Dr. Hamilton P. Traub on the status of *Crinum* breeding. For several hours we considered the many possible combinations, as well as the availability of many species and their hardiness in California. Dr. Traub said it was a dream of his to see a yellow color breakthrough in hybrid *Crinums* some day. He further suggested that I investigate the possibilities of achieving this end. Soon thereafter I conducted an in-depth survey of all available breeding material. The survey included hardiness, color, form, flower substance; in short, all the necessary qualities required by this project. Two candidates were finally chosen after much deliberation; i.e. a superb form of *Crinum bulbispermum* var. *album* grown in Fresno; and the yellow *Crinum flaccidum* from the Port Augusta region of South Australia.

According to the owner of the property where the Fresno plant was found, the plant had been there for over 70 years. This unique clone exhibited several characteristics which I felt were essential in achieving the yellow color. It had an unusual amount of greenish yellow, plus yellow pigmentation on both sides of the tepal segments and in the throat. Its tepal segments were curiously twisted which gave it a charming appeal (Figure 1). Since this clone was seed fertile and extremely hardy, I decided to use it as the seed parent.

The pollen parent from Australia is an outstanding species, exhibiting much variation in tepal length and width, and occurs in varying shades of yellow (Figure 2). It is accustomed to high temperatures in the summer and low in the winter. It appeared to have all the prerequisites necessary for this project.

The cross resulted in 30 seeds, all of which were potted, and then grown in one-gallon black plastic nursery containers, outside throughout the year, without any protection whatsoever. During the last three years, Fresno has experienced temperature extremes from 26 to 113° F. It is known that heat build-up in black nursery containers, placed in full sun, can reach 120° F. or more in extreme summer weather. Yet all plants survived, and three years later, the first of the group bloomed. This bloom was a beautiful ivory color with a slight hint of yellow on the edges of the tepal segments.

In the fourth year, another seedling put forth a beautiful light yellow bloom with a deeper yellow throat. It was a thrill to behold, to say the least! A second scape followed with 19 blossoms. The third scape increased to 21 blossoms, and finally, the fourth scape produced 30 unbelievably beautiful blooms.

To date, 25 of the 30 seedlings have bloomed. There have been many variations in color, tepal length and width, flower substance, foliage, and fertility. Only one, however, produced a yellow bloom.

This new hybrid is to be named *Crinum* X 'Yellow Triumph' (Figure 3). A mitotic chromosome count of $2n = 22$ was determined by Dr. Frank Willingham, Jr. of Research Farms, Houston, Texas, establishing this clone as diploid. Figures 4 and 5 showing the chromosomes of *Crinum* X 'Yellow Triumph' were provided by Dr. Frank Willingham, Jr.



Figure 1. Seed Parent—Superb form of *C. bulbispermum* var. *album* found in Fresno.

Figure 2. Pollen Parent—*C. flaccidum* from Port Augusta region, South Australia



Crinum X 'Yellow Triumph'

Description: Bulb 8.9cm (3 1/2") in diameter, 12.7cm (5") in height; leaves 18 to 24 per bulb, light green, 5.1-7.6cm (2-3"), and 182.9cm (6') in length, channeled, becoming strap shaped beyond midpoint, recurving, coiling up upon the ground, tapering to a point, edges scabrous; scape 45.7-71.1cm (18-28") in height; spathe-valve 12.7-15.2cm (5-6") in length, 3.8-4.4cm (1 1/2-1 3/4") in width; blossoms light yellow with deeper yellow throat, with some lime green on backs of tepal segments, reaching 8.9-10.2cm (3 1/2-4") in diameter; filaments 4.4-5.08cm (1 3/4-2") in length; anthers 7.9mm (5/16") in length; style 5.7cm (2 1/4") in length; tepal segments have a curious twist, 2.5-3.2cm (1-1 1/4") in width, and 6.4-7.6cm (2 1/2-3") in length; tepal tube 6.4cm (2 1/2") in length; pedicels 1.3-1.9cm (1/2-3/4") in length; pollen is amber colored and fertile; plant is hardy in California.

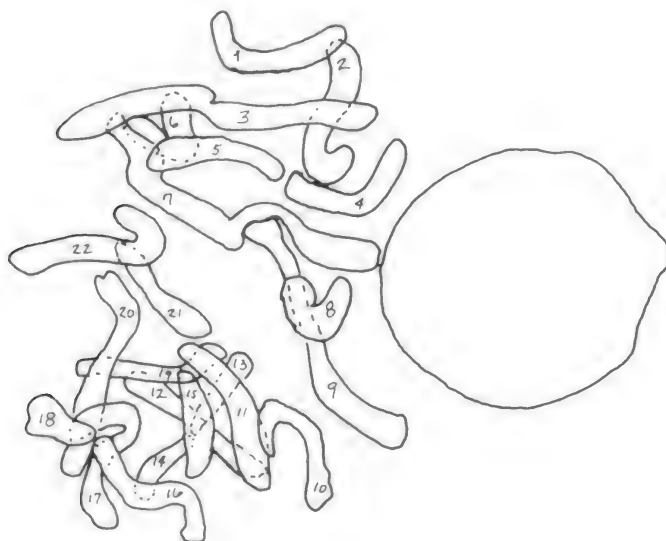


Figure 3. *C. X 'Yellow Triumph'* with comparison of white form of *C. moorei* on right



Figure 4. Mitotic chromosome preparation of *C. ×* 'Yellow Triumph' showing $2n = 22$

Figure 5. Interpretation of mitotic chromosome preparation of *C. ×* 'Yellow Triumph' $2n = 22$



HORTICULTURAL POTENTIAL OF **CYRTANTHUS** (AMARYLLIDACEAE)

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The genus **Cyrtanthus** comprises a group of some 50 species of tender African amaryllids. Only **Cyrtanthus purpureus**, the Vallota or Scarborough Lily, is commonly grown. Many of the other species are quite attractive, but while most species cross readily, only a few hybrids have been recorded (Mathew, 1978). There was an attempt, in South Africa, to produce a range of **Cyrtanthus** hybrids (McNeil, 1962). As in so many horticultural projects, Gordon McNeil was ahead of his time. The initial results were quite promising—but the project was later abandoned, and the plants appear to have been lost. Recently, a number of other breeders have started to examine this genus. Although the Vallota is of medium height, many other species are dwarves and would make good ornamental container plants. Other species can be used for bedding in warmer climates, and several have the potential for producing excellent cut flowers. **Cyrtanthus mackenii** and its variants are long lasting in the vase, and some are deliciously fragrant. Many species have the happy habit of producing several spikes per bulb; they readily form clumps, and some have several blooming flushes yearly.

The genus **Cyrtanthus** in South Africa was recently reviewed by Reid and Dyer (1984). East African species were revised by Nordal (1979) but are generally unobtainable. The UCI Arboretum has an extensive African collection of petaloid, monocotyledonous plants; within this collection are 22 of the South African **Cyrtanthus**. While some of these species are spectacular, prolific, and of easy culture: they are little known. Though many of the species have excellent ornamental potential, they can be improved upon substantially. Conversion to tetraploids will enhance their desirability, by producing larger flowers of even heavier substance. Furthermore, triploids can be produced by crossing polyploid species back onto diploids; these, while sterile, should make excellent flowers with long lasting characteristics and increased floriferousness. In addition, the UCI efforts are intended to extend the range of current hybrids. At UCI a **Cyrtanthus** breeding program was started several years ago and has flowered the first generation hybrids. While many of these are outstanding, the intent is to produce even better varieties—not only for the hobbyist and gardener but also the cutflower trade.

The following **Cyrtanthus** species are the backbone of the UCI breeding program:

CYRTANTHUS SANGUINEUS. This is a dwarf plant with leaves 15 to 20cm long and bears salmon-scarlet flowers often several to a cluster. Individual flowers are funnel-shaped and 8cm in length with petals recurving at the mouth so that the width is 6cm (Figure 1). Flower spikes are up to 20cm tall. Mature bulbs will produce three spikes per bulb and the plants readily form clumps. Cultural requirements are easy and like many other **Cyrtanthus**, the plants can tolerate much abuse. This species flowers at mid-summer and is evergreen (Figure 7).



Figure 1. *Cyrtanthus sanguineus* in the screen house, UC Irvine.



Figure 3. *Cyrtanthus smithii* + *C. sanguineus*.



Figure 4. *Cyrtanthus capensis* - *C. sanguineus*.



Figure 2. *Cyrtanthus brachysephyus*.

CYRTANTHUS BRACHYSCYPHUS. One of the smallest flowered varieties, it bears a cluster of 8 or more bright orange-red, narrow tubular flowers (Figure 2). The flowers are 1 to 1.5cm long by 0.7cm wide. Stems are 35cm tall while leaves are only 15cm long. This evergreen species has bright color, increased stem length, long lasting flowers, and individual bulbs continuously producing spikes. The flowering period has not been accurately determined but appears to extend for approximately half the year.

CYRTANTHUS MACKENII. A possible hybrid swarm with flowers varying from white to cream, pink and a variety of pastel colors. Flowers are also tubular, approximately 5cm long and 1.5cm across at the mouth; stems can reach 40cm in length. This species also has a long flowering period with several flushes of flowers occurring throughout the year. Many clones are heavily fragrant. This evergreen group has been used for the cutflower market in South Africa; they can be shipped dry and buds develop well in the vase. There is at UCI a strain of this plant, called 'Orange Gem,' that has three flushes of bloom during the year and reasonable numbers of off-season rebloom.

CYRTANTHUS SMITHII. This plant bears several large pendant, campanulate flowers that are white with pink stripes. The flowers and plants are slightly smaller than *C. sanguineus*. They have a restricted flowering period and are dormant during winter. The leaves, however, form spirals which add interest to the plant. A small amount of spiralling is apparent in its hybrids.

CYRTANTHUS CAPENSIS. This little known species has flowers similar to *C. smithii*. It has produced some nice hybrids and performs well in the greenhouse. The plants have strict dormancy requirements during the winter.

CYRTANTHUS FERGUSONIAE. This spectacular species has spikes about 60cm long, bearing up to 12 large tubular, scarlet flowers, 7 to 8cm long and 2cm wide. The plants are seasonal and deciduous. They clump readily and pass that feature onto their progeny.

CYRTANTHUS PURPUREUS. This is the well known Vallota. Flowers can be over 10cm wide on tall stems. Red and pink forms are known, with a white form rumored to exist. One supposed tetraploid strain is already available on the market. The species is seasonal, flowering during the summer and offsetting prolifically, but it is an unreliable bloomer. Some of its hybrids flower several times a year when grown under glass. It imparts size and stature to its progeny.

CYRTANTHUS MONTANUS. This is a newly available species with wide open flowers in an umbel reminiscent of a Nerine. It will have great hybridization potential for opening up the flowers and producing showy pot plants.

In addition to the above species, UCI has a range of hybrids that are fertile and will be used both for further breeding and ploidy conversion.

The hybrids we have flowered appear to have created quite a stir; this suggests they will find a ready home, at least among plant hobbyists. These plants mature and flower in about three years and can be maintained in small pots for several years.

CYRTANTHUS SMITHII × **C. SANGUINEUS**. Shades of pink through salmon flowers are produced in late summer; spikes with up to four, large, bell-shaped flowers are carried on a spike (Figure 3). Visitors found the colors very attractive. First time flowering, seedling bulbs produced up to three spikes in succession, giving a flowering period of eight weeks. All of the plants seem to be very fertile, both as pollen and pod parents. Second generation seedlings are now being grown from sibling and back crosses. Seedlings from these hybrids onto the *Vallota* have already germinated and are growing vigorously.

CYRTANTHUS SANGUINEUS × **C. CAPENSIS**. This cross was similar, but plants were slightly more robust. There are nuances of difference in the flower colors but they are difficult to define. Both strains were uniform in the quality of flowers produced, but there was some variation concerning the flowering time (Figure 4).

CYRTANTHUS SANGUINEUS × **C. FERGUSONIAE**. This cross produced taller flower stems, up to 16 inches, and some bulbs in the first flowering season produced two spikes (Figure 5). Some spikes had up to six flowers per stem. The color was a uniform, rich orange-red. Flower shape was intermediate between the two parents. The plants readily form clumps. This cross has limited fertility but we have obtained seed using pollen from the pink form of *Vallota*.

CYRTANTHUS SANGUINEUS × **C. PURPUREUS**. The idea of crossing the *Vallota* with **C. sanguineus** is an obvious one and has been produced several times internationally. Once again the flowers are intermediate between the two parents, although vegetatively the plants seem to be closer to the **C. sanguineus** parent (Figures 6 & 7). Plants at UCI appear to be sterile either as pod or pollen parents. Under glass they seem to flower twice a year.

CYRTANTHUS MACKENII × **C. SMITHII**. This cross produced smaller and much more subdued flowers than those of the earlier hybrids. Once again the flowers were basically salmon but had deeper stripes on some petals. Flower shape and vegetative growth is dominated by the **C. mackenii** parent.

At present nearly all UCI hybrids are in the orange to salmon shades. It should be possible to widen the range considerably by using species that possess other colors. Species do occur with white, yellow and pink flowers and the judicious use of the correct combinations should produce worthy hybrids in those colors. Considering the wide color range in the **C. mackenii** types cultivated in South Africa, it is surprising so little work has been done with this group. It is only in recent years that some of the South Africans themselves have recognized their untapped potential.

Cyrtanthus hybrids should find a ready acceptance by the gardening public once stocks become available. They have both pot plant and cut flower potential and can be grown in a cool greenhouse where they might be too tender for outdoors. Several species occur at high altitudes and could conceivably be used to transfer some cold tolerance to the hybrids.

Their potential for making acceptable cut flowers lies in the fact that one can make stems and florets of an acceptable size for florists. They are not as large and



Figure 5. *Cyrtanthus fergusoniae* × *C. sanguineus*.

Figure 6. *Cyrtanthus purpureus* × *C. sanguineus*.



unwieldy as hybrid *Hippeastrums* and unopened buds will still develop after being cut. It should be possible to produce umbels that contain eight or more flower buds. As Gordon McNeil foresaw so many years ago, this is a group that should have wide florists' appeal.

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Figure 7. *Cyrtanthus purpureus* × *C. sanguineus* with *C. sanguineus* for comparison.

VALLOTA SPECIOSA

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Although this splendid bulb no longer enjoys monotypic status in a genus of its own, it will be some time before the name goes out of usage. In 1984 Reid and Dyer, in *A Review of the Southern African Species of Cyrtanthus*, published **Vallota** as **Cyrtanthus purpureus**. Being a native of South Africa, it is not surprising that it finds Southern Californian climatic conditions much to its liking. The brilliant orange-scarlet flowers superficially resemble those of a small **Clivia**. In fact, when I first encountered it one June day 45 years ago, I thought it must be an off-season **Clivia** blossom. The flowers of both plants are of six "petals," are of comparable shape, in the same color range and carry conspicuous pollen-tipped stamens. They are surprisingly large for the size of the elliptical bulb and the sparse amount of foliage usually consisting of only four to six leaves about an inch or an inch and a half wide. Although the leaves are from 15 to 20 inches long they arch so that they rise to only about a foot in height.

The flowers are about three inches across and three to four deep. The umbel consists of two to ten blossoms but usually from five to nine with good culture and full maturity. These are carried on a sturdy stem up to two feet in length. The color of the flowers is quite variable. Some appear with a large area of white in the throat. Pure white flowers are available principally from England. I recall the excitement of discovering in pre-war days a cherry-red flower in a large block of bulbs at the late great horticultural establishment of Paul J. Howard in West Los Angeles (He was the brother of Fred Howard of \times **Amaricrinum howardii**). The R.H.S. *Dictionary* lists **V. alba**, white; **V. delicata**, salmon-pink; **V. elata**, cherry-red; and **V. eximiana**, white throat with crimson feathering, among others. Only the type has been commercially available in this country. It has never been common, but was available locally from J. N. Giridlean and Cecil Houdyshel for many years as well as from dealers in "Dutch bulbs" elsewhere. **Cyrtanthus purpureus** has been hybridized with **Cyrtanthus sanguineus**.

The bulbs flourish both as pot specimens and in the ground out-of-doors. They can take light, infrequent frost. As a pot plant, the bulb is usually placed just below the soil level. Out-of-doors it is often placed several inches below the surface. In England a depth of eight inches is recommended. At such a depth it is suggested that the bulb be surrounded by sand. As with some other bulbs, pot-bound specimens are reputed to be more floriferous, but actually they bloom well under good culture. They are very amenable to garden treatment.

In their native environment they grow in some shade. I have seen them flowering in Riverside close to the foundation on the north side of a house where light was good. The flowers last longer in good conditions in such a situation. Reid and Dyer state that "Forest species such as **C. purpureus** will not tolerate too much sun." Mine grew well in Riverside where temperatures soar to $100+^{\circ}$ F. for a week or two at a stretch. They received several hours of morning sun and, of course, were kept consistently moist. I have seen clumps of over a hundred bulbs flourishing and flowering with several hours of mid-morning sun. Many a grove house in days-gone-by in the Citrus Belt of Corona, Riverside, and Redlands cultivated this beautiful bulb in large numbers. Increase was

rapid from the generous number of bulblets produced each year and which matured in three years. They are also easily raised from the black, paper-thin seed resembling that of the hybrid **Hippeastrum**. The seed must be fresh. Reid and Dyer state that floating seed on water for two or three months results in 90-100% germination. However, one gets excellent germination by sowing seed shallowly on soil. I plant them on end rather than flat. The literature reports them as being deciduous, but under garden care they remain evergreen here.

Because of their native locale in South Africa, they are known as the George Lily or as the Knysna Lily. In England they are called the Scarborough Lily after the city of that name where they are widely cultivated; probably because of some climatic condition to their liking. There is a story that accounts for this situation. The bulbs are reported to have been washed up on the shore from the cargo of an ancient shipwreck. This story probably has no more foundation than the one relating how bulbs of **Nerine sarniensis** were similarly washed from a shipwreck onto the shores of the Isle of Guernsey. Nevertheless, it is odd that a city half-way up the North Sea coast of England should have given its name to these bulbs. The epithet has validity for England, but I have never heard anyone refer to it by any name other than **Vallota**. English sources were used by garden writers in the 1930's and 1940's whose articles appeared in *Sunset Magazine* and the home section of the *Los Angeles Times*. They always included something about "called the Scarborough Lily," but it never "took" here. Reid and Dyer state that bulbs were introduced into cultivation in England in 1774 by Frances Masson.

Today this eminently desirable and easily cultivated bulbous gem is rarely encountered because of the bulb or narcissus fly whose grubs can reduce a mature bulb to pulp in a matter of days. When the fly first became a serious pest, shortly after World War II, it was recommended that a tight groundcover such as Sweet Alyssum be planted to cover the point where the foliage emerges from the bulb to make it impossible for the fly to lay its eggs, but this proved ineffective. The only way to successfully cultivate this bulb today is under glass or screening. It is a grievous loss to the bulbous plants cultivated in the California garden.

STALKING THE **POLIANTHES** OF MEXICO—PART TWO, 1985

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In the summer of 1984 I made a special effort to collect **Polianthes** of central and western Mexico. Though the trip was very successful, another trip was necessary in 1985 to collect three as-yet-unpublished species growing in the state of Oaxaca in southern Mexico. All three species are quite rare and distinctive; two on the verge of extinction. I hoped to place a few under protective cultivation so they could be preserved via propagation. Their future in the wild is very bleak indeed. Fortunately, they are easy to grow and flower and readily hybridize with other species.

The adventure began in the city of Oaxaca. Driving toward Sola de Vega, on the road to the Pacific coastal town of Puerto Escondido, I hoped to re-collect **Polianthes** species #73-35, a pretty red-and-yellow flowered plant with the size and habits of the common single flowered tuberose. I had found it only once, in 1973, growing a few kilometers north of Sola de Vega on a rocky hillside amongst tall grasses. It was flowering in late July. Flowers were a bright orange-red externally, and yellowish on the inner surface. I have made repeated efforts since 1973 to re-collect this species, but all attempts have failed. The summer of 1985 was again to be one of those failures. While this species is undoubtedly rare, a few colonies might still exist; although the countryside is fairly wild, overgrazing is a considerable threat to these plants. The 1973 collection proved easy to cultivate, but our winters were too cold for this species. In the meantime, it easily hybridized with **P. tuberosa**; a few seedlings retained most of the characters of the Oaxaca parent, including coloring. Unfortunately, these hybrids too have since been lost due to poor winter management.

A few days later, on July 29, 1985, I left the city of Oaxaca and drove northward (and homeward) towards a rendezvous with yet another ultra-rare **Polianthes** species. This is a bit similar to **P. geminiflora**, save that the flowers are scarlet with green segments; the tubes a bit more inflated. The interior of the flowers is green. The red-and-green coloring gives it a "Christmasy" look. Originally this species, #68-239, was occasionally seen on rocky outcroppings above the highway here and there, but they have been blasted from their precarious habitats by road crews in an effort to remove the hazard of falling rocks. The rest have succumbed to the ever-present dangers of overgrazing. In 1973 I found a thriving colony of many hundreds of this species on a mountain side with a "microonda" (micro wave tower). There is a tiny ranch closeby in which resided an Indian family. Naturally, there were both goats and sheep grazing. It was obvious that the **Polianthes** were under grazing pressures, but it had then only started. Since, I have revisited this colony on several occasions, only to find it has dwindled continuously.

In this, my latest visit, I was hard pressed to find any plants at all. There were many more sheep and goats than before, and what few plants were found were stunted, with most bloom spikes decapitated by livestock. I did manage to find a few plants growing under **Opuntia** cactus, where they still were temporarily safe. I managed to dig a few plants, and as I was ready to leave, the little Indian "lady-of-the-house" approached my van and began fussing at me for digging her *plantitas*. She said they had been disappearing because of people like me. I felt a twinge, as I was

surely the only **Polianthes** "marauder" that has harvested from this colony over the years. The species is still unpublished and new to science.

I decided I would make the most of this confrontation. I pointed out the plants were diminishing due to overgrazing by "her" combination of sheep and goats—that we had never tried to deplete the colony. She doubted me at first, arguing that her animals "only ate the **leaves**" of her cherished plants! I pointed out the plants required their foliage in order to manufacture food, and needed to be allowed to flower and set seed in order to reproduce. We had a lively discussion; it was apparent she really loved and treasured these plants and was alarmed at their rapid disappearance from her hillside. After more discussion, she told me she once had gathered large bouquets for cut-flowers. I think I convinced her where the problem really was, and she promised to run the animals away from the colony by heaving stones at them. I seriously doubt it will have any effect, but I feel she better understands why her plants are almost gone. Too bad I did not talk to her about this years ago. It is a shame the last known colony of this pretty little species is doomed to extinction from overgrazing by goats and sheep.

This is another species that grows well in cultivation, but is quite susceptible to freezing if left in the ground during winter months. Most tender, Mexican deciduous bulbs winter quite well in my garden, but **Polianthes** normally grow so near the surface they're damaged by a hard freeze. It is pointless to plant them deeply since the bulbs simply elongate and come right back to the surface within a few growing months. They refuse to "stay put," and unless fairly frost resistant, they die. Digging and storing is the answer, but this is something we seldom do in the deep South.

Hopefully I left the little Indian woman in a better frame of mind. By then she had warmed up to me, and even called her husband so she could introduce him. He was a very old man with grey whiskers who seemed bewildered about his wife making such a fuss over a few wild flowers. It is difficult for people to grasp the function of leaves to a plant, when they assume livestock are "supposed to eat" the green leaves. They have trouble distinguishing between leaves of grasses and those of rare plants like **Polianthes**.

This part of Oaxaca (Yanhuitlan vicinity) is depressingly eroded and overgrazed. The goats only serve to magnify and reinforce this problem—making a poor land poorer.

The next day found me in northern Oaxaca, where there grows yet another new species of **Polianthes** with red and yellow flowers. These are found but a few miles north of Huajuapán de León. They are safe from cultivation yet under "familiar" pressures. The grazing here is largely from cattle and horses, but is not as yet intense. Even so, we found decapitated flower stems here and there, indicating that livestock browse them on a regular basis. I first collected this species in 1974, under my collection number 74-95. Unlike the others, this species has proven to be among the hardiest, and is easily maintained in cultivation. Flowers are orange-red with yellowish interiors and are among the more successful species to hybridize with **P. tuberosa**. The hybrids, known as 'Sunset,' retain some of the tuberosa fragrance coupled with the pretty red and yellow coloring of the Oaxaca species.

I managed to find a good colony spread widely over a small hillside that would make specimens for future publication. I left this collection site in much better spirits, feeling this species might be around for another decade or so before finding itself threatened with extinction.

A few days later I was in central Mexico, in the city of Guanajuato, "winding-up" our trip before heading homeward. The city is situated at around 6000 feet, but the road north towards Dolores Hidalgo, on Mexico 110, climbs considerably higher as it crosses a mountain range. In these mountains, to my surprise, was another *Polianthes* quite different from those of southern Mexico. This one was something of an enigma. Colors of the flowers varied from a good coral-red, through shades of pink and rose, cream to nearly white.

In some ways they reminded me of *P. geminiflora*, but these were obviously not that species: they had a faint fragrance, and of course the paler shades were wrong. In retrospect, this collection (#85-65) seems closest to plants taken near the border of Jalisco and Guanajuato in the Lagos de Moreno region, and dubbed "Little Stinker." The latter plants have a fragrance which may be pleasing, but some remind one of rancid butter. Mrs. Morris Clint first collected this plant years ago, and she remarked about its color variability. In 1965 I first collected it under my number 65-59. I have collected it several times since under other numbers. I will need additional study to compare the latest collection (85-65) with "Little Stinker" to see how they differ other than color. Apparently, I may now have a new locale. At any rate, this must be the most variable colored species in the genus. They seem fairly safe, as the country is wild; but even so, livestock grazing occurs. Is there anyplace where livestock grazing does not occur in Mexico? No place seems so remote that goats or burros are not munching away nearby.

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(Please advise the Editor of interesting literature you encounter)

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CRINUM 'EMMA SWETS'

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Crinum 'Emma Swets' is an example of the excellent hybrids now appearing. The flowers are very beautiful having a crystalline quality about the recurved tepal segments which are $\frac{3}{4}$ -1 inch wide. The tepal segments are soft ivory white with wine pigmentation fusing throughout. Blossoms reach 7-9 inches in diameter and are intensely fragrant. The form of the flower is quite elegant and crisply formed; not at all floppy. This hybrid is of average size having a bulb about 3 inches in diameter. It is of moderate increase, producing two or three offsets per year. It is amazing that such a small bulb will throw 5-6 scapes over a long season from May to November. These scapes are about 2 feet tall displaying an umbel of from 10-16 flowers. The scapes are green with much wine pigmentation. The foliage is relatively slight being 18-24 inches in length by $1\frac{1}{2}$ -2 $\frac{1}{2}$ inches in width and is bright green in color. This plant does not appear to set seed. Pollen is golden yellow and fertile.

The parentage is unknown since it was grown from a batch of seed collected by Les Hannibal in his garden near Sacramento. Possibly one parent is **Crinum americanum**. It is named for Emma Swets who for over 50 years was Riverside's "bulb lady" and who was a dear friend of both L. S. Hannibal and the author.

The bulb is hardy and grows best in full sun, being undaunted by temperatures of 113°. It is briefly deciduous. Due to its many fine attributes, **Crinum** 'Emma Swets' has excellent breeding potential.



Crinum 'Emma Swets.' Herbert Kelly, Jr. photo.



